The

PSYCHOLOGICAL RECORD

Vol. I | OCTOBER, 1937 | No. 19

AN EXPERIMENTAL STUDY OF FORM PERCEPTION IN THE THERMAL SENSES

LAWRENCE JOSEPH STONE
Sarah Lawrence College

The Principia Press, Inc.
Bloomington, Ind.

Price of this number $1.50

TABLE OF CONTENTS

Chapter One. Introduction.

Chapter Two. The First Experiments.

Chapter Three. Experiments With Radiant-Heat Pattern.

Chapter Four. Simplification Experiments.

Chapter Five.

Interpretation and Theoretical Implications of the Findings.

Chapter Six.

CHAPTER ONE—INTRODUCTION [1] *

I. Setting the Problem

It is some 250 years since the temperature senses were differentiated from the 'sense of touch', and, at least since Weber's time, this sense-division has been generally recognized scientifically. But in the long history of research in the problems of form perception, there has been no concern with form perception in the thermal modalities. The variety of papers dealing with aspects of tactual form perception is in striking contrast with the absence of such investigations in the temperature senses.[2] This is true if we consider only the material in the field of 'passive' touch (which is analogous to our investigation), and ignore the relatively vast literature on tactual-kinesthetic patterns. (Toulouse and Vaschide [43] among others make this distinction between "état statique" and "état dynamique".)]

The original purpose of the author was to carry on in the field of thermal perception some of the work which, in vision, has been considered to afford crucial evidence for the presence and activity of 'internal forces': forces determining perception in certain fixed ways *(Prägnanz)*. In the warm- and cold-senses there has been no *training* in form perception, as may occur in vision, and, since the laws of 'good form', of 'closure', etc., are held to be basic laws of the entire nervous system and of shapes in general [29 pp. 132-149], we would have something in the nature of a crucial case for determining the actual generality of these principles, and for deciding whether they are

[1] The author is deeply grateful to Professor A. T. Poffenberger, who directed this study, for constant advice and warm encouragement. Thanks for frequent consultation and assistance are due Professors K. M. Dallenbach, Kurt Goldstein, Gardner Murphy, Max Wertheimer and R. S. Woodworth and Dr. J. P. Seward.

The genuine cooperation of the following observers was invaluable: A. L. Benton, R. F. Brown, R. W. Browning, A. Dimino, J. Eisenstat, D. M. Johnson, H. D. Kaye, E. Meyers, M. L. Morris, H. W. Pope, A. Pressman, R. Reade, V. Rosenfield, E. Schwitzke, R. B. Taylor and O. Thorngren.

[2] In conversation Professor Max Wertheimer has informed me of some unpublished work of his in this field, which constitutes the only approach to it that we have been able to discover.

* Manuscript recommended by Dr. J. R. Kantor, August 19, 1937.

merely characteristic of vision, or, at least, of 'trained' senses. However, an examination of the literature showed that we have no knowledge whatsoever in this field, and it became logically necessary first to establish the general conditions for perception of thermal patterns (patterns or forms perceieved by the mediation of the receptors for cold or warm, alone). Thus, the main field for our research may be stated as follows: *Is there thermal form perception?* Secondary problems which arise from this are: *How accurate is thermal form perception?; What factors* (in the physical set-up or in the observer) *affect thermal form perception,* and *in what way?* In the course of the investigation certain additional theoretical questions demanded consideration.

The body of this paper presents a more or less chronological record of a series of experiments on these problems. The nature of the work makes it desirable to present each experiment as a unit and on the basis of the results to show the experimental logic that led to the next step. Although the term 'exploratory investigation' has a tiresome ring, and has been used as a cloak for much that is slipshod and *empirical* in the poorer sense of the word, it is necessary to emphasize that this is, precisely, exploratory work, and suffers many of the disabilities of such research. Thus, it has been impossible to set up specific hypotheses for testing in crucial experiments. There was no data on which to construct such hypotheses. One could only follow leads and clues while practicing the closest possible cross-check between theory and experiment. The outcome has been, then, not the solution of such crucial problems in the theory of perception as were originally envisaged, but the extension of the problems into new and unexpected fields which promise richer reward in theoretical resolution. The value of the present paper may lie primarily in its fruitfulness for future research.

We may anticipate by reporting that, in general, no correspondence whatsoever has been found between the pattern of the thermal stimulus and the verbal description of the thermal experience, although there is evidence of gross spatial organization. Thus, this work has suffered the logical tortures not alone of preliminary 'unsyllogistic' research, but the equally racking ones of negative results. An extreme caution in the interpretation of such results is inevitable in the presence of the slightest scientific sophistication, and though the author is reluctant to take the view that further refinements of method would fail to find positive results, all the evidence now at hand indicates the validity of this assumption.

The step-by-step presentation will mirror the development of theory, out of research, and preliminary to research, and show the succession of negative findings despite the adoption of one new technique after another. The unexpected theoretical problems which have forced themselves to the foreground may best be discussed after the experimental portion of this paper. At this point we shall merely sketch the background against which the work was begun.

On an *a priori* basis it appeared probable that there should be more or less clear, and more or less objectively accurate perception of thermal patterns. A modality subserved by spatially distributed receptors [12] should show some spatial organization. The main problem, apparently, was to devise apparatus by which thermal patterns could be presented in purity, and to determine the correspondence between stimulus-pattern and experience-pattern.

II. Literature on Passive Form Perception in the Touch Sense

On the analogy of tactual perception there should be no question of the matter. Beginning with the work of Major in 1898 [32] there are almost a dozen studies dealing with passive form perception by way of the touch sense. Major, commenting on the absence of any literature on the subject, set himself the problem of determining "the limen of form at various parts of the cutaneous surface." The forms he used included a 35° angle, an open circle, a filled circle (disk) and a filled triangle, the dimensions varying from 2-12 mm. "The judgment of cutaneous form was . . . recorded in terms of a visual translation. This procedure recommended itself in view of the fact that movement was above all things to be avoided; we were investigating the cutaneous not the tactual [passive not active] perception of form." In ability in "form cognition" the skin surfaces used ranked as follows: tip of tongue, tip of finger, lips. The form most easily cognized was the circle: results were far more satisfactory with the circle than the disk. It was also determined that "Practice at a given spot increased the subject's power of discrimination . . . of form at that spot. And practice at a spot of finer discrimination was . . . of influence upon the cognition of form at spots of coarser discrimination." A further point which has bearing on our own material is the statement in reference to the judgments at subliminal levels, which are said to "tell their own tale of individual tendency."

Except for incidental reference in such works as Langfeld and Allport's [31] laboratory text, where an experiment is suggested in which cardboard forms are pressed down on the skin surface, the field lay fallow until 1926. In that year, two papers dealing with the problem were published. Bose and Kanji [5] attacked the problem with the same type of material as Major, but, unlike him, attempted to eliminate the factor of visualization. Using 13 subjects, they presented wooden blocks of two different sizes, bearing raised circles, triangles and rectangles. A standard and variable were used, on the forearm of the subjects. "The instruction to the subject was that he should try to judge whether the second stimulus is the same as or different from the first. He should not try to guess or visualize. . . . Any factor other than the tactual is to be regarded as secondary. The secondary factors should be reported if they appear in spite of the instruction." (p. 75.) It was found that S relied very largely, though involuntarily, on such secondary factors,

their percentage among all answers varying between 53% and 90%. Three main categories of report were distinguished: 1. Visual images; 2. Secondary dermal factors (weight, temperature, etc.); 3. Pure guess factors. Taking those answers where secondary factors were absent the ratio of correct to incorrect responses was 1.06 to 1.30. The authors' conclusion is that there is "No evidence . . . to show that we directly perceive forms in terms of touch without any aid from secondary factors." (p. 100.)

In the same year Zigler and Northup [51] attempted to determine "(1) the degree of accuracy with which observers can render judgments as to the form, or shape, of certain common geometrical figures applied to the skin with vision excluded; (2) the psychological processes involved in the perception of tactual form and in particular the more salient features by which the forms of these figures are primarily apprehended; and (3) the rough determination of that magnitude around which the threshold for the perception of these forms lies." (p. 39.) The forms employed were a square, equilateral triangle, right angle triangle, diamond and hexagon. The main dimension of each form was 20 mm., and the weight about 500 mm. The volar surfaces of the left forearm, midway between the wrist and elbow of four observers were tested. In a considerable percentage of cases tactual form was not definitely given, and in an appreciable number not apprehended at all. Only one observer secured as high as 50% accuracy and that the one who knew the figures used. The results were worse when stimuli with main dimensions of 35 mm. were employed. "When form is most clearly given, tactual processes alone carry the meaning of the particular shape. A definite and complete form, however, was the exception rather than the rule in our experiment. The more typical reports of all observers show that shape is not usually mediated by tactual processes only." (p. 394.) The realization of form was minimal where pressure was totally devoid of outline, and maximal where the completed contour was given in terms of the tactual impression. Between the extremes were intermediate degrees of definiteness of form, where salient topographical features of the tactual impression were perceived in isolation and completed in visual or tactual imagery.

Stimuli of 5, 10, 15, 20 and 25 mm. in their main dimension were used in another part of the experiment. "The stimuli of 5 and 10 mm. quite generally gave rise to the perception of a mere point or a blunt point of shapeless pressure. In the few instances when the forms of the 10 mm. stimulus were correctly reported, the shape was described as very indefinite and the judgment as essentially a guess. The minimal magnitude of stimulus for the passive apprehension of shape in the region stimulated seems to fall between 10 and 15 mm. The optimal dimension seems in general to be 20 mm." (p. 396.)

In 1927 Zigler and Barrett [50], following up the Zigler-Northup study, determined more definitely some of the stimulus factors in form perception, and outlined more clearly the nature of the perceptual process involved. Again 500 gm. forms of hard rubber were used, the main dimensions being 12, 14, 16, 18 and 20 mm., the volar surface of the forearm, the palm and the ball of the thumb were employed. The forms used were solid, outline or "pointed." "The last were constructed by mounting small rounded points of 2 mm. elevation at the juncture of adjacent sides of the figure." (p. 185.)

As in the previous study "the triangles were correctly perceived much more frequently than the other figures," (p. 186) totaling more than two-thirds of all correct judgments. The hexagon was very poor. "It is evident that the figures whose sides form acute angles give more definite tactual clues to the physical character than do those whose sides form right or obtuse angles. This is probably due to the fact that the pressure gradient of acute angles is steeper than that of right or obtuse angles." (p. 186.) The per-

ceived form of the pointed figures was found in the introspective reports to be frequently supplemented by tactual 'tied-images' or by visual imagery. Four steps of positiveness (certainty) judgments were required—65-85% of 'very positive' judgments were accorded to the triangles, although less than one-fifth of all the judgments fell in the upper two degrees of certainty. Outline figures were found to be superior to the other types. The thumb was superior to the hand, which, in turn, surpassed the arm. When the observers were able to detect the temporal course of the process, three stages were distinguished which may overlap or may be arrested before completion: (1) a stage of shapeless pressure or pressure-blur; (2) a stage in which one or two salient features of the form acquire definiteness or clearness; (3) the stage in which outline is clearly and completely given.

In a Columbia University Master's essay [36] in 1927—published in abbreviated form in 1929 [37]—Rosenbloom took up the problem with the expressed purpose of checking the operation of certain Gestalt principles in tactual perception. Specifically he wished to know: Are some figures more easily perceived than others? If so, what are their characteristics? Do incomplete forms tend to be completed? Are parts influenced by the whole? Does the figure have properties not contained in its parts? The stimuli used consisted of brads nailed close together, with a 1 lb. weight resting on each; the forms were a circle, equilateral triangle, square, incomplete circle, three sides of a square, a right angle (or two sides of a square) and a triangle with the apex missing. The area of each closed figure was 3.14 sq. in. Ten subjects were used, each of the forms being presented five times on the palm of each. The instructions stipulated that a geometric form would be used, and the subject was required to name or draw it as quickly as possible, guessing if necessary. Reports of certainty (0, 1, 2) were required, and the reaction time recorded. Rosenbloom found that his subjects were more certain of their correct than their incorrect responses. The percentage of correct reports with each stimulus is given below:

TABLE I
(Part of table on p. 88 [37])

Stimulus	*% Correct*
Circle	80
Square	50
Triangle	80
Open Circle	54
Open Square	40
Right Angle	74
Open Triangle	6

The distribution of reports is shown in Table II.

TABLE II.
(from p. 89 [37])

	Circle	Square	Triangle	Open C.	Open Sq.	Rt. Angle	Open Tr.
Circle	40	0	0	4	0	0	0
Square	0	25	3	0	3	0	0
Triangle	0	0	40	0	0	0	1
Open C.	9	1	0	27	1	0	0
Open Sq.	0	8	4	4	20	1	1
Rt. Angle	0	0	6	2	0	37	0
Open Tr.	0	0	32	1	0	0	3

A second experiment compared the two-point threshold as secured with the ordinary compass method with the threshold obtained as the distance between the ends of the two legs of an open triangle. The fact that with the latter method the limen was, on the average, 19.4 mm. as compared with 8.4 mm. by the traditional method was taken as evidence that the figure influences its component parts.

De Gowin and Dimmick, in 1928 [23] attempted to push further the analysis begun by Major, Bose and Kanzi, Zigler and Northup, and Zigler and Barrett, by obtaining "descriptions of the spatial patterns of several touch perceptions whose stimuli have definite visual patterns and to determine whether, as in the case of vision, tied images play any part in these patterns." (p. 114.) The forms used were a line, circle, equilateral triangle and square. Five untrained and two trained subjects served in the experiment. "At first there was no perception of form in the usual (visual) sense . . . the patterns of the perception which were vague and indefinite at first soon became fairly exact and consistent." (p. 118.) Other findings were: purely tactual perceptions do not naturally take on the meanings of form to correspond with our usual geometrical forms; when such tactual perceptions of form are built up it is only by the addition of other elements, usually visual; in spite of their lack of resemblance to the visual forms of the stimuli the tactual patterns are stable and readily recognized; tied images play a great part in filling out the tactual patterns from incomplete stimuli.

Bromberg and Schilder [6] mention in passing, in connection with a study in a related field, that "Tactual impressions of an object give few hints of the nature of the object provided one does not move the fingers."

Franz, in 1933 [18], used training in tactual form perception as the basis of experiments in cross education or bilateral transfer. Six stimuli—linoleum cuts—were used: a square with each of the four sides broken, three sides of a square, a Greek Xi, a capital Z, an X and a circle. These were presented in random order, with two to five presentations before a judgment was required, the subjects then being required to select the correct stimulus from a card with visual representations of all the forms. Six female subjects were used, with application of the stimuli above the wrist and above the patella. A preliminary test series was followed by training and retest series and by tests on other areas. Chance correctness would have been 5, whereas the average on the series varied from 8 to 15. Training raised the score to as high as 29 for the wrist, with similar results for the thigh, and for contralateral and transverse areas which were not used in the training series. Similar results were obtained in another experiment [19], using the same general technique.

Franz and Kilduff [20], in the following year, performed a related experiment, using, on this occasion, two linoleum blocks, one with a straight line 38 mm. long and 1 mm. wide, and one with two lines, each of half the length of the first, forming a 135° angle; the area used was the right forearm. Before training 20 out of 40 responses were correct, while after training 36 to 38 were correct. Other untrained areas after the training on the forearm showed 34 to 37 correct.

In an experiment reported in the same year [33], Martin gives a regrettably incomplete account of his experiments, using a modification of the technique suggested in Langfeld and Allport's text. He made use of ten shapes: circle, ellipse, square, rectangle, triangle, four-pointed star, five-pointed star, hexagon and octagon. These were 1 inch in diameter, cut of sheet metal and soldered to handles. The stimuli were applied in irregular order to the palm, volar surface of the forearm and the cheek. The subject was required to name the shapes, although it is not clear whether he worked

with knowledge or not. A tactual-kinesthetic procedure was also employed, the subject placing on his finger a thimble to which a point was fastened, with which he was to trace the boundaries of the figures. Using passive touch the percentage of correct responses on the palm was 62.9, on the forearm 33.9 and on the cheek 36.4. With kinesthesis the average of correct responses was approximately 74%.

Oberto [35] reported in 1936 on the "threshold for rectilinearity." He used an ingenious apparatus, but only a single observer, the author himself. Three points were so arranged that they could be placed on the arm with two of the points in a straight line, while the angular position of the third could be varied. The total extent could also be varied. *O* reported whether or not he felt a straight line. The averages of his determinations indicate that a deviation of about 12° 15′ is detectible with the points covering 10 mm., while a deviation of as little as about 1° 30′ can be noted when the two end points are 70 mm. apart. For distances between these extremes the angular values vary accordingly.

The findings of the experiments presented chronologically above, may be conveniently summarized under several headings.

A. *Ability to Perceive Tactual Patterns.*

With the possible exception of Bromberg and Schilder all authors agree that tactual patterns may be perceived with some objective accuracy, apparently depending in amount upon conditions of the experiment. With knowledge of the stimuli to be employed and with sharp definition of outlines accuracy may run as high as 97.5% (Franz).

B. *Conditions Limiting Accuracy of Perception of Tactual Patterns.*

1. Size. There is a size threshold for tactful form perception. Naturally it varies from region to region (Major, Oberto, Zigler and Northup, Zigler and Barrett). Zigler and Northup suggest that there is also an upper limit beyond which form perception is less accurate.

2. Region. Various regions of the body have been used as the experimental skin-surfaces. The arms apparently are superior to the thighs (Franz), while the palm is better than the forearm (Zigler and Barrett, Rosenbloom, Major). The thumb and fingertips surpass the palm in tactual form sensitivity (Major, Zigler and Barrett), while the tip of the tongue is reported as the most sensitive (Major). This order of sensitivity follows the ranking in terms of density of 'touch-spots' and the order of decreasing magnitude of the two-point limen, a finding which one might logically expect.

3. Intensity. Although no systematic variation of the pressure exerted upon the stimuli has been reported, there are indications that

such variations would be found to have significant effects on the reports of patterns. Zigler and his co-workers, and Rosenbloom report the necessity of using rather intense pressure to secure satisfactory reports of patterns. In a number of the studies the stimuli were applied by hand with no way of controlling the amount of pressure used.

4. Outline vs. Solid Forms. Major, Zigler and Northup, Zigler and Barrett, find definite superiority of outline figures over surface or filled figures in ease of perception. Further, a comparison of studies using one or the other type of figure (e.g., Rosenbloom, Franz—but not Martin), indicates the same trend.

5. Nature of Stimulus Forms. See Section D, below.

6. Effect of Practice and Training. See Section D, below.

C. *Nature of Perceptual Process.*

The bulk of the available evidence leads to the conclusion that while the shapes of tactual stimuli are reported, it is very difficult or perhaps impossible to obtain such perceptions in purely tactual terms. Bose and Kanji point out that while reports of form are still secured, their accuracy drops to about a chance level when 'secondary factors' (visual images, secondary dermal cues) are absent. Zigler and Northup indicate that, typically, the experience is not mediated by tactual processes alone, although in some cases—in contradiction to Bose and Kanji, cases where the clearest and sharpest forms are perceieved—pure tactual processes are all that can be observed. De Gowin and Dimmick, who concentrated on this problem, maintain that purely tactual perceptions do not take on the meaning of form without the addition of other, visual, elements. These 'tied images' are found to be of great importance. Because of the difference of opinion then, we cannot decide finally whether visual imagery is indispensable to tactual form-perception, or merely very common. It is possible that theoretical predilections would lead to a conclusion in which 'meaning' of form would be regarded not as an absolute, but something which must be added on by 'tied images', or what-not. At any rate, there is strong evidence that patterning is not a necessary accompaniment of tactual experience.

The *temporal course* of the experiences has been described. (See Zigler and Barrett.)

C. *Effect of Practice and Training.*

Major, in 1898, and DeGowin and Dimmick thirty years later mention incidentally the marked influence of practice on accuracy and clearness of tactual form perceptions. Franz and his co-workers conducted a series of experiments where training was the essential feature of the research, and found improvement from 50% (chance) success before training, ranging to almost 100% accuracy following the training. Both Major and Franz *et al.* report the spread of the influence of training from the region trained to other parts of the body surface.

D. *Experimental Findings and Gestalt Principles.*

1. Forms Most Readily and Accurately Perceived. A reading of Gestalt psychology suggests that the 'inner tensions' of the optic system—and of the nervous system in general—would be such that the 'best form', *i.e.*, the form most readily perceived correctly, and the form toward which incorrect perceptions would tend is the circle. Koffka [29, p. 139] says, for instance, "we should expect very stable organizations whenever the two kinds of forces [those which exist in the nervous process, tending toward the simplest possible shape, and those between this process and the stimulus pattern, which constrain the stress toward simplification] act in the same direction, if, e.g., our spot has circular shape."

The expectation that the circle is the 'best' form is confirmed by Major who points out that "*the form most easily cognized . . . is the open circle*" and that "the filled circle was as unsatisfactory as the open circle was satisfactory to work with" [32 p. 146]. Rosenbloom, on the other hand, found the circle and the triangle equally correctly perceived, and the right angle, as shown in the table reproduced on page 239, is very slightly poorer. Zigler and Barrett, as well as Zigler and Northup, found the triangle best of the forms they used, which did not include the circle. The reason they suggest for the superiority of the triangle is that figures with acute angles are able to produce "more definite tactual clues to the physical character than do those whose sides form right or obtuse angles . . . [because] the pressure gradient of acute angles is steeper than that of right or obtuse angles." Thus we have two very different kinds of shapes—circles and triangles—which are almost equally effective in producing stable and objectively accurate organizations. The triangle, as Koffka says [29 p. 152], "particularly if it is an isosceles or an equilateral one, is simple, possesses symmetry, and the reason for the segregation of the

whole area may well be this symmetry, which should be accompanied by stability."

2. Closure. In the only experiment dealing directly with this question Rosenbloom found evidence of the operation of a tendency toward closure, or completion of "incomplete' figures. This may be seen by an examination of the errors in the table on page 12. The open circle was felt as a circle 9 times, while it was felt as other forms only twice. The open square was perceived as a square 8 times, more often than it was perceived as any other (incorrect) figure. The open triangle was perceived as a triangle 32 times, while it was perceived as an open circle once, and an open triangle (correct) only 3 times! It is curious that the triangle was so much more affected by the operation of the principle of closure than the circle; this is an unexpected result.

In the second part of his experiment—that on the two-point threshold—Rosenbloom obtained what may be considered as a measure of the strength of the force of closure. The two-point limen was more than twice as large when the two points were the ends of two sides of a triangle as when the points were discrete. It is perhaps unfortunate that a circle was not used instead of a triangle, since the force of closure should be more clear-cut in the latter case. His experiment may be criticized on the ground that the mass of stimulation which is present when he uses the incomplete triangle makes the situation different from that in the compass method, and makes it difficult to say how much of his results should be attributed to the factor of closure.

As has been pointed out, no comparable experimental background exists for the thermal modalities, but on the basis of apparent similarity between the tactual and thermal senses it was assumed that using adequate equipment, the existence of thermal form-perception might be readily demonstrated, and that in view of the absence of training of such perception in daily life, it would be possible to obtain crucial evidence on the existence and operation of laws of form-percention—such as the Law of Prägnanz, for example—which many psychologists [44] have held to be the result not of fundamental characteristics of the nervous system, but rather of training and familiarity with simple geometric forms.

CHAPTER TWO—THE FIRST EXPERIMENTS

I. Experiment 1.

This experiment was reported in somewhat different form in an unpublished Master's essay [41]. It deals with the attempt to demonstrate patterning of experience in the cold sense.

A. *Apparatus.*

It was necessary to devise a new type of apparatus, meeting certain requirements:

1. We must be able to present cooled forms.

2. We must control or eliminate other cutaneous stimulation, especially pressure, which might give extraneous cues.

3. Our forms must have clear, sharp boundaries.

4. It must be possible to maintain constant temperature at the level desired.

The most difficult requirement to satisfy was the second. Working with cold, not warmth, it was not easily possible to employ a 'radiant' source. Instead of *eliminating* pressure, therefore, we held it constant, while the pattern of cold was varied. To accomplish this the cold stimulus form was placed within a disk of hard rubber, always of the same size and shape. Rubber was selected because of its low specific heat and low thermal coductivity, facilitating the production of sharp boundaries. The disk was 2 in. in diameter and ⅜ in. thick. Three copper forms were used, a disk (D), a triangle (T), and a rectangle (R). See Fig. 1. These were equated so that the maximum dimension of each was 1¼ in.

The construction of the stimulators is shown in Fig. 2. Directly attached to the copper form, and fitting into the hard rubber disk, is a metal tube 5 in. high, which is fitted to the copper form by a water-tight joint, and closed at the top. Into the rubber-stopper are inserted glass inlet and outlet tubes. These are connected to rubber tubing. Also inserted in the stopper of each of the three stimulators is a thermometer enabling the experimenter to determine the temperature within the stimulator at any time.

A constant flow of water is maintained at the proper rate by the apparatus shown in Fig. 3. In the reservoir water is maintained at a constant level by the flow from the faucet through the rubber intake tube and the provision for overflow when the level is too high. A large quantity of ice maintains the temperature in the bucket at about 0° C. From the outlet this cooled water flows to the inlet tube of whichever stimulator is to be used, the selection of the stimulator being determined by the pinchcocks. From the outlet tube of the stimulator, the water is carried away to the drain. The temperature of the stimulator is determined by the rise in temperature of the water after it has left the bucket. This, in turn, is affected by the rate of flow, which is controlled by varying the height of the standard supporting the reservoir;

we have, thus, a gravity feed. During the experiment this apparatus was arranged so that a few moments after directing the water to the desired stimulator, the temperature within it dropped to between 8° and 9° C, and remained at that level as long as desired.

STIMULATORS—CONTACT SURFACES

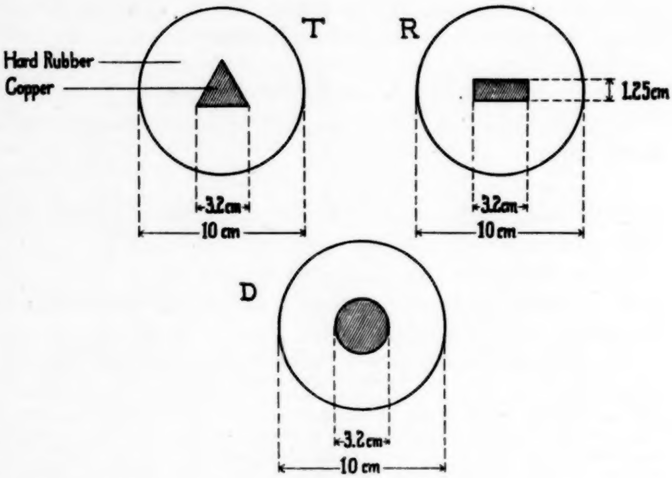

Fig. 1

B. Experimental Region.

The most convenient region to use, in terms of the desiderata of obtaining a large, relatively flat surface, and high density of cold-spots [42] was the lower chest and abdomen. The precise areas employed lie within the epigastric region, the umbilical region, and small portions of the lumbar regions adjacent to the umbilical. The experimental surface was divided into eight roughly equal-sized areas, each of which, in order, was used once during each session of the experiment.

It may be noted here that the size of the stimulators was determined after the selection of the experimental region.

C. *Procedure.*

The observer, stripped to the waist, lay on a mattress placed upon a large table, the entire apparatus being screened from his vision. At

the 'ready' signal he closed his eyes, and the proper stimulator was placed on one of the eight areas for a period of 2 seconds. *O* then made his report, while the flow of water was directed to the next

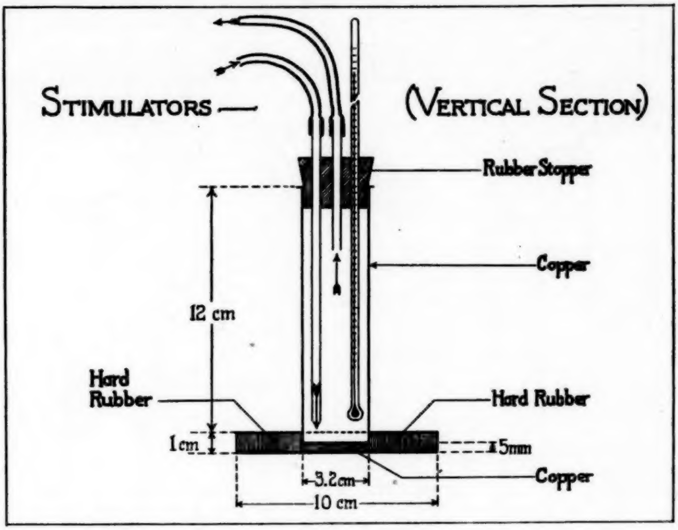

Fig. 2

stimulator by the experimenter. Just before presentation the hard rubber was warmed by hand to insure its remaining at a neutral temperature.[1] Eight stimulations were given at each experimental session; there were 12 sessions in all for each of the 3 observers. A planned 'random' order was employed for the rotation of the stimulators, such that each was used on each area (and therefore in each of the temporal positions) an equal number of times.

It is important to note that during the entire course of the experiment the *O*s were in entire ignorance of the number and nature of the stimuli.

D. *Instructions.*

The following instructions were read to *O*:

"After a 'Ready, Now' signal, an object will be placed on your abdomen, corresponding to the circle on this report-sheet. Within the circle you will

[1] Occasionally the hard rubber alone was tried on the skin, and was never called cold, justifying our assumption that there was no appreciable spread of cold from the copper forms.

feel cold. You are to describe this cold that you experience as accurately as possible, particularly, where you can, as regards its shape. You are also to draw it on the report-sheet as well as you can within the circle representing pressure. Do you understand?"

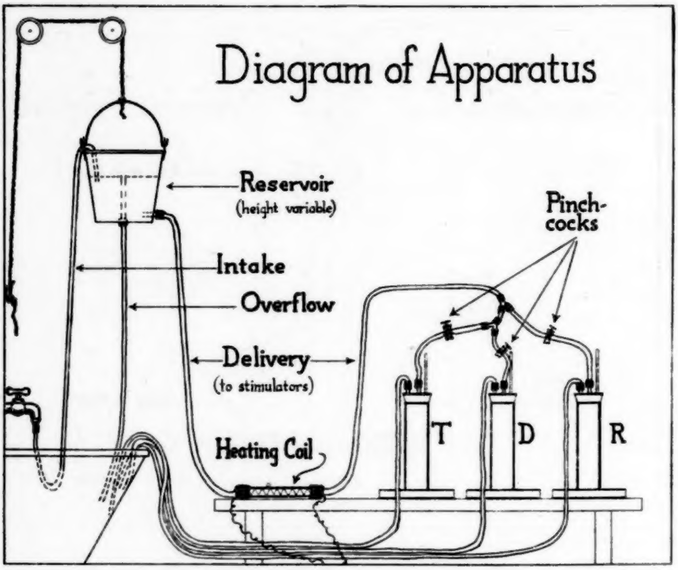

Fig. 3

A report-sheet was provided, which gave a space for *O*'s verbal report, a circle of the same size as the hard-rubber disk in which to draw the shape perceived, and a space for the experimenter's remarks.

E. Observers.

*O*s were graduate students in psychology at Columbia University. They are designated as *Be, Po* and *Ta.*[1]
search.

The experiment took place between April and June, 1934.

F. Results.

The raw data of this experiment consist of 288 verbal reports and drawings, 96 from each *O*.

[1] Our *O*s, in this experiment only, knew the general nature of the research.

1. Are Forms Perceived?

Our first concern is to determine whether the reports indicate the possibility of form perception: are the reports mainly of vague, essentially unformed cold experience, without patterning, or are figures and patterns reported?

Tables III-a, III-b and III-c present this information in a summarized form. Because of the small number of *O*s, and the individual differences in their results, we have, throughout, treated the data separately for each *O*. In these tables the reports for each observer

TABLE III—a

Showing, for *Be*, the Proportion of Cases in Which Forms Were Reported, and the Relation of Such Reports to the Stimulator Employed.

		Absolutely Formless	Vaguely Formed	Part Definitely Formed	Completely Definitely Formed
Total for each stimulator in each category of report	D	0	1	0	31
	R	0	0	0	32
	T	0	4	0	28
Percentage for each stimulator in each category of report	D	0	20	0	34
	R	0	0	0	35
	T	0	80	0	31
Total for each category of report		0	5	0	91
Percentage of total in each category of report		0	5	0	95
Percentage, in each category, of the total for each stimulator	D	0	16	0	84
	R	0	3	0	97
	T	0	0	0	100

TABLE III—b

Showing, for *Po*, the Proportion of Cases in Which Forms Were Reported, and the Relation of Such Reports to the Stimulator Employed.

		Absolutely Formless	Vaguely Formed	Part Definitely Formed	Completely Definitely Formed
Total for each stimulator in each category of report	D	0	2	10	20
	R	1	0	16	15
	T	1	2	20	9
Percentage for each stimulator in each category of report	D	0	50	22	45
	R	50	0	35	34
	T	50	50	43	21
Total for each category of report		2	4	46	44
Percentage of total in each category of report		2	4	48	46
Percentage, in each category, of the total for each stimulator	D	0	6	31	63
	R	3	0	50	47
	T	3	6	63	28

TABLE III—c

Showing, for *Ta*, the Proportion of Cases in Which Forms Were Reported, and the Relation of Such Reports to the Stimulator Employed.

		Absolutely Formless	Vaguely Formed	Part Definitely Formed	Completely Definitely Formed
Total for each stimulator in each category of report	D	3	7	11	11
	R	5	5	9	13
	T	10	4	12	6
Percentage for each stimulator in each category of report	D	17	44	34	37
	R	28	31	28	43
	T	55	25	38	20
Total for each category of report		18	16	52	30
Percentage of total in each category of report		19	17	53	31
Percentage, in each category, of the total for each stimulator	D	9	22	34	34
	R	16	16	28	40
	T	31	13	37	19

have been divided into four categories, ranging from 'Absolutely Formless', through 'Vaguely Formed', 'Part Definitely Formed' to 'Completely and Definitely Formed'. Experiences characterized by such phrases as "a cold object of vague shape" (*Ta* -I-1-T),[1] "cold seemed small, and directed, rather than definitely bounded" (*Ta* -II-4-T), or "general cold and pressure—not sure of shape" were included in the category 'Absolutely Formless'. For the category 'Vaguely Formed' we have such descriptions as "a curved area" (*Ta* V-8-D), "felt as though the whole was equally cold, and was vaguely circular" (*Ta* -III-2-D), or "Vague—but about that size [as in his drawing] and broader than it was deep" (*Ta*-VIII-6-R). The category 'Part Definitely Formed' includes those reports in which a portion of the cold area was described as formed, and the remainder essentially formless, or not bounded. The 'Completely and Definitely Formed' category includes figures that were completely bounded, with little or no doubt expressed as to the definiteness of these boundaries.

Table III-a, summarizing the results for *Be*, shows that almost 95% of his reports fell in the group of completely bounded, definite forms, with none indicating complete absence of form. These results are radically different from those for each of the other *Os*. Almost all of *Po*'s reports (Table III-b) are approximately evenly divided between 'Part Definitely Formed' and 'Completely and Definitely Formed', while *Be* had no reports in the former category. *Ta*'s reports (Table III-c), again, show a very different picture, with almost 19% in the 'Absolutely Formless' category, almost 17% in the 'Vaguely Formed' category, and the remaining two-thirds of the reports about equally distributed in the 'Part Definitely Formed' and 'Completely and Definitely Formed' categories.

It seems fair to conclude (with due allowance for the small number of observers, and the variation among their reports), that *cold patterns are perceived,* and perceived with considerable completeness and definiteness.

2. *Was Form More Readily Perceived with Any Specific Stimulator?*

There is no evidence that any of the three patterns produced more complete or definite experiences of form than any other. The percentage of reports in each category of definiteness that is associated

[1] This notation will be used to identify quotations from the *Os*' reports. The first symbol indicates the *O*, the Roman numeral the experimental session, the Arabic numeral the number of the experiment within the session, and the final letter indicates the stimulator used in that trial.

with each stimulator reveals no consistent superiority. In Table III-a (*Be*'s results) this is immediately apparent; in Table III-b (*Po*'s results) there is some suggestion that the disk produced reports of more definite forms, while Table III-c (*Ta*'s results) suggests that somewhat clearer forms were produced by the rectangle.

3. *With What Accurary Are Forms Perceived?*

Having determined that forms *are* perceived in response to cold-stimulus patterns, and perceived with some definiteness and completeness, it is necessary to determine the objective accuracy of such perceptions. Do the patterns reported correspond accurately to those of the stimuli? In what proportion of the cases? Is there any *systematic* variation from complete objective correspondence?

Tables IV-a, IV-b and IV-c show, for each experimental session, the patterns reported in association with each of the three stimulators (stimulus-patterns). In general the responses are readily classified under ten categories, with an eleventh added for 'miscellaneous' figures —*i.e.*, those difficult to classify, or unfamiliar.

TABLE IV—a

Showing, for *Be*, a Classification of the 95 Forms Reported, and the Relation of Such Reports to the Stimulators Employed.

Category:	Stimulus	Circle	Ellipse	Semi-Circle	Semi-Ellipse	Crescent	Triangle	Wedge	Rectangle	Diamond	Open Rectil. Fig.	Misc.
Total for each stimulator in each category of report.	D	13	12	3	1	1	0	0	0	1	0	1
	R	10	21	0	0	0	0	0	0	1	0	0
	T	14	15	0	0	0	1	0	0	0	0	1
Percentage for each stimulator in each category of report	D	35	25	100	100	100	0	0	0	50	0	50
	R	27	44	0	0	0	0	0	0	50	0	0
	T	38	31	0	0	0	100	0	0	0	0	50
Total for each category of report		37	48	3	1	1	1	0	0	2	0	2
Percentage of total in each category of report		39	50	3	1	1	1	0	0	2	0	2
Percentage, in each category, of the total for each stimulator	D	41	38	9	3	3	0	0	0	3	0	3
	R	31	66	0	0	0	0	0	0	3	0	0
	T	45	48	0	0	0	3	0	0	0	0	3

TABLE IV—b

Showing, for *Po*, a Classification of the 91 Forms Reported, and the Relation of Such Reports to the Stimulators Employed.

Category:	Stimulus	Circle	Ellipse	Semi-Circle	Semi-Ellipse	Crescent	Triangle	Wedge	Rectangle	Diamond	Open Rectil. Fig.	Misc.
Total for each stimulator in each category of report	D	3	1	0	0	0	14	10	0	0	0	4
	R	0	0	0	1	3	12	6	0	0	3	5
	T	0	0	1	0	1	6	16	0	0	1	4
Percentage for each stimulator in each category of report	D	100	100	0	0	0	44	31	0	0	0	31
	R	0	0	0	100	75	37	19	0	0	75	38
	T	0	0	100	0	25	19	50	0	0	25	31
Total for each category of report		3	1	1	1	4	32	32	0	0	4	13
Percentage of total in each category of report		3	1	1	1	4	36	36	0	0	4	14
Percentage, in each category, of the total for each stimulator	D	10	3	0	0	0	43	31	0	0	0	13
	R	0	0	0	3	10	40	20	0	0	10	17
	T	0	0	3	0	3	21	55	0	0	3	14

TABLE IV—c

Showing, for *Ta*, a Classification of the 63 Forms Reported, and the Relation of Such Reports to the Stimulators Employed.

Category:	Stimulus	Circle	Ellipse	Semi-Circle	Semi-Ellipse	Crescent	Triangle	Wedge	Rectangle	Diamond	Open Rectil. Fig.	Misc.
Total for each stimulator in each category of report	D	5	1	0	1	5	0	5	2	0	2	2
	R	5	1	0	1	3	2	5	2	0	2	1
	T	2	1	0	0	5	0	6	1	0	2	1
Percentage for each stimulator in each category of report	D	42	33	0	50	38	0	31	40	0	33	50
	R	42	33	0	50	23	100	31	40	0	33	25
	T	16	33	0	0	38	0	38	20	0	33	25
Total for each category of report		12	3	0	2	13	2	16	5	0	6	4
Percentage of total in each category of report		19	5	0	3	21	3	25	8	0	10	6
Percentage, in each category, of the total for each stimulator	D	22	4	0	4	22	0	22	9	0	9	9
	R	23	5	0	5	14	9	23	9	0	9	5
	T	11	6	0	0	28	0	33	6	0	11	6

There are striking individual differences: these will be considered below. Characteristic, however, is the outstandingly clear tendency for the reports to be *massed* within certain categories (different for each *O*). In Table IV-a we find almost 90% of the classifiable reports in the Ellipse and Circle columns; in Table IV-b over 70% are in the Triangle and Wedge (or incomplete triangle) categories. In Table IV-c there is more scattering, but we still find over 65% of the reports classifiable in three categories: the Circle, Crescent (incomplete circle), and Wedge (incomplete triangle). Some powerful factor other than the mere stimulus situation appears to be operating. One of our tasks will be to discover this factor.

In terms of the immediate question we are asking—how accurately are patterns perceived?—the massing of the data implies that the correspondence between stimulus-pattern and experienced pattern can not be very high. Tables IV-a to IV-c bear out this supposition. In each of the tables, categories 1, 6, and 8 (Circle, Triangle and Rectangle) correspond to the stimuli used. *Be* reported 37 disks, but they were associated with the three stimulators in approximately equal proportions; that is to say, stimulators T and R were as likely as D to call forth the experience of a disk. If we consider the other category containing an appreciable number of reports—that of Ellipses—the same fact may be observed. Thus we may summarize the table for *Be* by saying that he tended to report circles and ellipses, to the virtual exclusion of other types of forms, and that no stimulator was more likely than any other to elicit such reports. Objective accuracy is practically zero. *Po*'s table shows almost the same result. His data are massed under the categories Triangle and Wedge, but the triangle stimulator was no more successful than the disk or rectangle in arousing a 'triangular experience'. The table for *Ta* presents a very similar situation. The only possible deviation from what is apparently a pure chance distribution of his reports (in each category) among the three stimulators is found in the Circle and Triangle categories. There are definitely fewer reports of Circle associated with the T stimulator than with the other two—although they are equally divided between the D and R stimulators. The other deviations are almost undoubtedly attributable to chance, in view of the relatively small number of reports in each category.

The tables can be examined with another point in mind: namely, to determine the proportion falling into each category of the reports for each stimulator, counting only the cases where form was perceived. Thus, in Table IV-a, over 40% of the reports associated with (in

response to) the D stimulator were correct, *i.e.*, fell into the Circle category. If we consider the items falling under the next four categories as at least partially correct, we strike the very high figure of over 90% of the reports partially or completely correct. However, the distribution of the reports for the three stimuli is almost the same, and gives no indication of accurate discrimination. This result was clearly foreshadowed at the beginning of this section, when the massing of the data considered as a whole was discussed. The other two tables do no present so clear-cut a parallelism of the distributions for the three stimulators, but the trend is obviously the same.

The conclusion must be drawn that, under the conditions prevailing, and with the apparatus used, there is *no consistent relationship* between stimulus-pattern and experienced pattern of cold. One stimulus is as likely as another to produce a given report of form.

It should be pointed out that in all the tables (III, IV or those that follow), the results would be precisely the same if we showed the results separately for each experimental session. It is a striking fact that in this experiment the results of Session I are indistinguishable from those of Session XII. This is true of all *Os*.

4. *Accounting for the Forms Reported.*

The conclusion reached in the preceding section raises the question as to what *does* determine the forms perceived, since the nature of the objective stimulus seems to be utterly ineffective. The striking differences among the three *Os* demonstrate the small influence of the stimulus, and point to the primacy of 'internal' factors. *Be* tended to report circles (and disks) and ellipses, *Po* reported a heavy preponderance of complete and incomplete triangles, while *Ta* reported a wider variety of patterns, but with a weighting on the two types 'preferred' by the other *Os*.

a—'Stimulus' and 'Object.' Two possibilities occur as likely explanations for the reported patterns. The first of these might be summarized in Woodworth's distinction [49, p. 361] between the 'stimulus' and the 'object'. The term 'object' signifies the *real thing* 'out there' in the 'world'. The 'stimulus' represents the actual *physical energy* distribution that impinges on the sense-organs (See also Koffka [29] on the 'geographical' and 'behavioral' environments). It is possible that the 'stimulus' is quite different from the 'object'—*i.e.*, from the stimulator as known to the experimenter. In other words, the receptor pattern-on-the-skin, for a variety of reasons, may be different from the stimulator pattern, and the reports may be correct in terms of the

'stimulus' (skin pattern); the factors accounting for the lack of *objective* accuracy would then be those causing the difference between the skin pattern and the stimulator pattern.

We may suppose a number of such factors. First the stimulator itself should be considered. Is the pattern of cold as sharp and clear as it appears visually? There appears little reason to doubt this. The very high thermal conductivity of the copper form assures a temperature practically the same as that of the circulating water, and the water circulated so rapidly that even placing the stimulator on the warm skin caused no observable rise in temperature. Further, the extremely low conductivity of the hard rubber around the form was such that there was no detectable difference in temperature between the outer part of the rubber and the portion close to the copper. However, we believe it quite possible that the boundary of *pressure* (created by the gradient present around the outside of the hard-rubber—the edge of the stimulator) was close enough to the boundary for cold to influence it, either by *assimilation* to the pressure boundary (which would account for the nature of *Be*'s reports, of disks, etc., although not those of *Po* and *Ta*), or by simple *interference*, acting as a confusing or distracting factor, which would increase the importance of 'internal' factors. An attempt was made in Experiment 2 to take account of this possibility.

Turning from the stimulus to the receptor surface we find a number of conditions which might account for the negative results obtained. First, we might consider the thermal characteristics of the skin itself, which might permit enough spread of thermal stimulation (conducted by the skin) to destroy the sharp boundaries of the stimulus. If so, the same objection that was raised above would appear again: such an hypothesis would account for *Be*'s results but not for *Po*'s and *Ta*'s, in which angles were involved. Putting that to one side for the moment, let us face the possibility. Indirect evidence is available on the basis of an incidental observation. Several times, immediately after the removal of the stimulator, its pattern could be clearly seen on *O*'s skin, as a result of the response of the vasomotor system. The pattern, in such cases, was quite sharply outlined, and easily recognizable *visually* by the experimenter. The thermal coefficient of the skin as a tissue is unknown, but it appears unlikely, on the basis of the two points raised above, that it represented an important factor. However, much more likely to be of influence is the distribution and function of the receptors subserving the cold sense. If we assume that we are

dealing with discrete,[1] mosaically distributed cold-sensitive spots,[2] we may point out the possibility that the distribution of the cold-spots is such that it does not correspond to the objectively created pattern on the skin. It is possible, for example, to conceive of a circular stimulus arousing (by chance) a group of cold-spots so distributed as to form a triangle. Or, the distribution might be such as to arouse no clear form, but rather to throw the responsibility of 'creating' form again on the 'internal' factors. This possibility is a very serious one, and must be taken into account. It would follow, on such a basis, that a stimulus arousing a pre-existing *pattern of cold-spots*—such as a triangular group—would result in the experience of a triangle. To test this possibility, it would be necessary to secure a map of a number of stable cold-spots, and to design an apparatus with which one could select a *given pattern* of points and stimulate *only those points*.

A number of difficulties have prevented our performing such an experiment; in any case, this hypothesis is not likely to be correct, in view of the fact that each *O*'s type of report was so specific for the individual.

b—If we assume, on the basis of what has gone before, that the patterns reported by the subjects are inaccurate objectively (which we know to be true), and in terms of the pattern of cold-spots aroused (which would seem likely in view of the large divergences among the subjects), we must ask the question why forms were reported at all. The instructions to the *Os* (p. 247) specifically *call for reports of shape,* and assume that shapes will be perceived: it is entirely possible that the reported experiences of pattern are produced by the *set,* which is a function of the instruction [2, p. 29]. Further, the concept of an *Einstellung* for form accounts readily for the individual tendencies to perceive different forms noted above. It may be supposed that the set for a *particular kind of form* was present before the first stimulation

[1] The statement that we are dealing with 'discrete' spots does not necessarily imply a crudely mosaic or summative view of their function. Thus, the Gestalt psychologists, for example, think of distinct rods and cones, which nevertheless are considered to affect each other; to function, in fact, as an organic whole rather than in a summative fashion. Nor does 'mosaic' psychology exist today except as a foil.

[2] The nature of the *end-organ* for cold (or warmth) is unknown. At present it is thought by one group of investigators to be an undifferentiated nerve ending [12, p. 427]; by another to be a receptor in the wall of small blood-vessels, aroused by their contraction [34]. The present author leans to the former view. He feels that there is sufficient evidence to show that the cold-*spots* (not end-organs) are discrete, and the discovery of new spots with more intense stimuli, cited as contradictory evidence, is merely a function of differential 'tuning', or threshold. See also p. 319.

and continues throughout. It is noteworthy in this connection that there was practically no variation in any O's pattern of reports from the first series to the last. For example, the proportion of disks and ellipses reported by *Be* was as high in any single series as in the totals, presented in Table IV-b.

This 'imaginal' characteristic of the reports does not disqualify them: ". . . the present day psychology of perception admits that the distinction between sensory and imaginal elements is purely logical and not psychological; and, in the second place, the comparison of a perception with an exposure field can be made only upon the assumption that the stimulus is physical and not physiological." [11, p. 144.]

It will be noted immediately that this theory accounts better for the results with *Be* and *Po* than it does for those with *Ta*. The difference between the first two and the latter has been emphaized several times before. It is possible, of course, that *Ta* had a more flexible set for *form in general* than the other *O*s, whose tendency to report circular or triangular forms has been sufficiently mentioned above. However, there is a possibility that the difference lies in a difference of *attitude*. From the comments of *Ta*, we may say that he was concerned with avoiding what Titchener called the stimulus-error. (In Woodworth's terms, he tended to adopt the stimulus-attitude rather than the object-attitude.) It is our belief that such an attitude prevented the predominance of any single type of form in his reports. Such an attitude might result in the presence of a number of predispositions for various forms, held more or less in abeyance, with each report a sort of *resultant* of the cold-spot pattern, and the particular form-set dominant at that moment. Or, we may think of a more complex set involving several possibilities—a set for variety. The fact that this *O* reported fewer patterns than the others is probably significant in showing the influence on him of the stimulus-set and the relatively weaker influence of any form-set.

This factor of the *influence of instruction* was partly studied in a experiment reported below. (See Experiment 7.)

Major [32, p. 147] reported in his work on tactual form perception that the *O*s' judgments of form when the stimuli were *subliminal* in terms of size, told "their own tale of individual tendency". The suitability of this description to the reports of our *O*s is striking and may mean either that our own stimuli are subliminal in size or that for the other reasons suggested the 'external forces' are insufficient to determine the experienced patterns unequivocally and that 'individual tendency' is the necessary result in such a situation. This is one of the

factors concerning whose influence no final decision has been reached. An additional factor which might have limited accuracy was the relatively brief period of stimulation. In subsequent experiments this was increased.

7. *Summary.*

We have seen that forms are perceived, whether correctly or no. As Dallenbach has pointed out, (see p. 260) lack of objective accuracy does not prevent our speaking of perceptions. It is abundantly clear, however, that the patterns reported are highly inaccurate. More than this, the impressive individual differences and their consistency indicate the preponderant influence of 'internal factors', or 'individual tendency'.

Several lines for future investigation, then, were indicated by this experiment, rather than any definite positive result. It became necessary to determine the causes for the ineffectiveness of the objective pattern. It has been suggested that size, interference by the experience of pressure, the pattern of receptors stimulated, etc., are all influential in restricting the accuracy of the reports. We also pointed to the nature of the instructions and the *O*'s attitude as causing forms to be reported and as determining their nature. The experiments reported below were designed, in part, to investigate these problems.

II. Experiment 2.

The present experiment was conducted under the same general conditions as the one preceding, except that the stimulus was not cold but warmth. Correcting only minor faults of the previous experiment, it was designed to determine whether, under similar conditions, any differences would be found between the two modalities.

A. *Apparatus.*

The apparatus was similar to that of Experiment 1 in all but two respects. The diameter of the hard-rubber annulus was increased to 4 inches, with the thought in mind that when the pressure gradient was removed thus far from the thermal pattern the possible interference effect of the pressure (p. 258) would be diminished or abolished. The other change was required by the shift from cold to warmth. A section of glass tubing was introduced into the water circuit between the reservoir (see Fig. 2) and the stimulators. In the glass tubing was placed a two-foot coil of Nichrome wire, connected to the 110 v. D. C. current by an iron-core variable resistor used as a potentiometer, and

supplying a 7 amp., 7 v. current. The temperature of the stimulator was again controlled by the gravity feed: lowering the source decreased the rate of flow of the water past the Nichrome coil and raised the temperature of the stimulator. The temperature of the stimulator, as before, was read from the thermometer inserted within it. The variation was less than half a degree around 40° C.

B. *Experimental Region.*

In order that the results might be generally comparable the same region was used as in Experiment 1—the lower chest and abdomen. The region, this time, was divided into 9 areas, each of which was stimulated once during each experimental session.

C. *Procedure.*

The procedure differed from that in Experiment 1 only in the time of stimulation, which was now unlimited; for we had thought the brief time of stimulation in the earlier experiment might be a handicap. *O* signaled, in this experiment, when he was ready to make his report. The average stimulation time desired by the *Os* was around 15-20 seconds. Since the first experiment showed no change in the nature of the reports from the first series to the last, three sessions of nine stimulations each were deemed sufficient.

D. *Instructions.*

O's instructions were as follows:

"After a 'Ready, Now' signal, you will feel a disk on your abdomen, whose outline corresponds to the circle on this report-sheet. *Within* this area you will feel an area of *warmth*. You are to describe the warmth-experience as accurately as you can, particularly, where you find it possible, in terms of its shape. You are also to draw it as well as you can within the circle representing the pressure-outline on the report-sheet. Your report should be limited to your *experience*: try to avoid thinking in terms of the *object* eliciting the experience. Do *not* fit your description to any guess you may make regarding the nature of the stimulus—limit yourself to the pattern of *what you feel*."

The report-sheet contained spaces for the *O*'s report and for his drawing which was made in a circle, the same diameter as the rubber disk.

E. *Observers.*

The *Os* were five undergraduate volunteers, members of a class in Experimental Psychology, with the exception of one *(Ro)* who was

beginning graduate work in Psychology. They were *Br, Jo, Me, Ro* and *Th*. The experiment was conducted in April, 1935.

F. Results.

1. *Are Forms Perceived?*

The raw data consist of 135 verbal reports and drawings, 27 from each *O*. Tables V-a to V-e show the data on the possibility of perceiving form. Like Tables III-a to III-c, they divide the reports into categories ranging from 'Absolutely Formless' to 'Completely and Definitely Formed'. One new category has been added: '*Part* Vaguely Formed', indicating that a portion of the region was vaguely patterned.

Table V-a, giving the results for *Br*, indicates a strong tendency to perceive forms: all but one stimulation resulted in a report classifiable as 'Part Definitely Formed' or 'Completely and Definitely Formed'. The next table, giving *Jo*'s results, presents an even more striking tendency in the same direction: all of his reports could be classified as 'Completely and Definitely Formed'. Table V-c and V-e, for *Me* and *Th*, present much the same picture. V-d, giving *Ro*'s results, however, is almost startlingly different, showing a heavy preponderance of 'Formless' reports.

TABLE V—a

Showing, for *Br*, the Proportion of Cases in Which Forms Were Reported, and the Relation of such Reports to the Stimulator Employed.

		Absolutely Formless	Vaguely Formed	Part Vaguely Formed	Part Definitely Formed	Completely Definitely Formed
Total for each stimulator in each category of report	D	0	0	0	5	4
	R	0	0	0	4	5
	T	0	1	0	3	5
Percentage for each stimulator in each category of report	D	0	0	0	42	29
	R	0	0	0	33	36
	T	0	100	0	25	36
Total for each category of report		0	1	0	12	14
Percentage of total in each category of report		0	4	0	44	52
Percentage, in each category, of the total for each stimulator	D	0	0	0	56	44
	R	0	0	0	44	56
	T	0	11	0	33	56

TABLE V—b

Showing, for *Jo*, the Proportion of Cases in Which Forms Were Reported, and the Relation of such Reports to the Stimulator Employed.

		Absolutely Formless	Vaguely Formed	Part Vaguely Formed	Part Definitely Formed	Completely Definitely Formed
Total for each stimulator in each category of report	D	0	0	0	0	9
	R	0	0	0	0	9
	T	0	0	0	0	9
Percentage for each stimulator in each category of report	D	0	0	0	0	33
	R	0	0	0	0	33
	T	0	0	0	0	33
Total for each category of report		0	0	0	0	27
Percentage of total in each category of report		0	0	0	0	100
Percentage, in each category, of the total for each stimulator	D	0	0	0	0	100
	R	0	0	0	0	100
	T	0	0	0	0	100

TABLE V—c

Showing, for *Me*, the Proportion of Cases in Which Forms Were Reported, and the Relation of Such Reports to the Stimulator Employed.

		Absolutely Formless	Vaguely Formed	Part Vaguely Formed	Part Definitely Formed	Completely Definitely Formed
Total for each stimulator in each category of report	D	0	1	0	0	8
	R	0	1	0	0	8
	T	0	0	0	0	9
Percentage for each stimulator in each category of report	D	0	50	0	0	32
	R	0	50	0	0	32
	T	0	0	0	0	36
Total for each category of report		0	2	0	0	25
Percentage of total in each category of report		0	7	0	0	93
Percentage, in each category, of the total for each stimulator	D	0	11	0	0	89
	R	0	11	0	0	89
	T	0	0	0	0	100

TABLE V—d

Showing, for *Ro*, the Proportion of Cases in which Forms Were Reported, and the Relation of such Reports to the Stimulator Employed.

		Absolutely Formless	Vaguely Formed	Part Vaguely Formed	Part Definitely Formed	Completely Definitely Formed
Total for each stimulator in each category of report	D	5	1	0	2	1
	R	6	1	0	0	2
	T	4	1	1	2	1
Percentage for each stimulator in each category of report	D	33	33	0	50	25
	R	40	33	0	0	50
	T	27	33	100	50	25
Total for each category of report		15	3	1	4	4
Percentage of total in each category of report		55	11	4	15	15
Percentage, in each category, of the total for each stimulator	D	56	11	0	22	11
	R	67	11	0	0	22
	T	45	11	11	22	11

TABLE V—e

Showing, for *Th*, the Proportion of Cases in Which Forms Were Reported, and the Relation of such Reports to the Stimulator Employed.

		Absolutely Formless	Vaguely Formed	Part Vaguely Formed	Part Definitely Formed	Completely Definitely Formed
Total for each stimulator in each category of report	D	0	1	0	0	9
	R	0	1	0	0	7
	T	0	1	0	0	8
Percentage for each stimulator in each category of report	D	0	33	0	0	38
	R	0	33	0	0	29
	T	0	33	0	0	33
Total for each category of report		0	3	0	0	24
Percentage of total in each category of report		0	11	0	0	89
Percentage, in each category, of the total for each stimulator	D	0	10	0	0	90
	R	0	12	0	0	88
	T	0	11	0	0	89

The reason for *Ro*'s deviation from the 'norm' (*i.e.*, the results with the other four *Os*), will be found below. Disregarding *Ro*'s results for the moment, we may conclude that *patterns of warmth are perceived;* if we may assume that conditions were really comparable, they are perceived with even greater completeness and definiteness than was true in the case of cold patterns.

As in the last experiment, there is no evidence whatsoever for the superiority of any of the three stimulator patterns in producing complete or definite experiences of form.

2. *With What Accuracy Are Forms Perceived?*

We have determined that in the modality of warmth geometric forms are reported; under our conditions, even more readily than in the cold modality. It is desirable now to examine the data to see whether warm patterns are any more accurately related to the objective stimulus.

Tables VI-a to VI-e, like Tables IV-a to IV-c, give the distribution of reports in terms of shape.

TABLE VI—a

Showing, for *Br*, a Classification of the 27 Reports, and the Relation of Such Reports to the Stimulators Employed.

Category:	Stimulus	Circle	Ellipse	Semi-Circle	Semi-Ellipse	Crescent	Triangle	Wedge	Rectangle	Diamond	Open Rectil. Fig.	Misc.
Total for each stimulator in each category of report	D	2	0	1	0	0	0	0	0	0	0	6
	R	2	1	2	1	0	0	0	0	0	0	3
	T	3	0	0	1	0	0	0	0	0	0	5
Percentage for each stimulator in each category of report	D	28	0	33	0	0	0	0	0	0	0	43
	R	28	100	67	50	0	0	0	0	0	0	21
	T	43	0	0	50	0	0	0	0	0	0	36
Total for each category of report		7	1	3	2	0	0	0	0	0	0	14
Percentage of total in each category of report		26	4	11	7	0	0	0	0	0	0	52
Percentage, in each category, of the total for each stimulator	D	22	0	11	0	0	0	0	0	0	0	67
	R	22	11	22	11	0	0	0	0	0	0	33
	T	33	0	0	11	0	0	0	0	0	0	55

TABLE VI—b

Showing, for *Jo*, a Classification of the 27 Reports, and the Relation of Such Reports to the Stimulators Employed.

Category:	Stimulus	Circle	Ellipse	Semi-Circle	Semi-Ellipse	Crescent	Triangle	Wedge	Rectangle	Diamond	Open Rectil. Fig.	Misc.
Total for each stimulator in each catgory of report	D	2	5	0	0	0	0	0	1	0	0	1
	R	2	3	0	1	0	0	0	0	0	0	3
	T	3	4	0	0	0	1	0	0	0	0	1
Percentage for each stimulator in each category of report	D	28	42	0	0	0	0	0	100	0	0	20
	R	28	25	0	100	0	0	0	0	0	0	60
	T	43	33	0	0	0	100	0	0	0	0	20
Total for each category of report		7	12	0	1	0	1	0	1	0	0	5
Percentage of total in each category of report		26	44	0	4	0	4	0	4	0	0	19
Percentage, in each category, of the total for each stimulator	D	22	55	0	0	0	0	0	11	0	0	11
	R	22	33	0	11	0	0	0	0	0	0	33
	T	33	44	0	0	0	11	0	0	0	0	11

TABLE VI—c

Showing, for *Me*, a Classification of the 27 Reports, and the Relation of Such Reports to the Stimulators Employed.

Category:	Stimulus	Circle	Ellipse	Semi-Circle	Semi-Ellipse	Crescent	Triangle	Wedge	Rectangle	Diamond	Open Rectil. Fig.	Misc.
Total for each stimulator in each category of report	D	6	0	0	0	0	0	0	0	0	0	3
	R	4	3	0	0	0	0	0	0	0	0	2
	T	4	2	0	0	0	0	0	0	0	0	3
Percentage for each stimulator in each category of report	D	42	0	0	0	0	0	0	0	0	0	37
	R	29	60	0	0	0	0	0	0	0	0	25
	T	29	40	0	0	0	0	0	0	0	0	37
Total for each category of report		14	5	0	0	0	0	0	0	0	0	8
Percentage of total in each category of report		52	18	0	0	0	0	0	0	0	0	30
Percentage, in each category, of the total for each stimulator	D	67	0	0	0	0	0	0	0	0	0	33
	R	44	33	0	0	0	0	0	0	0	0	22
	T	44	22	0	0	0	0	0	0	0	0	33

TABLE VI—d

Showing, for *Ro*, a Classification of the 27 Reports, and the Relation of Such Reports to the Stimulators Employed.

Category:	Stimulus	Circle	Ellipse	Semi-Circle	Semi-Ellipse	Crescent	Triangle	Wedge	Rectangle	Diamond	Open Rectil. Fig.	Misc.
Total for each	D	1	0	0	0	1	0	0	0	0	0	7
stimulator in	R	0	1	0	0	1	0	0	0	0	0	7
each category of report	T	0	0	0	0	1	0	0	0	0	0	8
Percentage for	D	100	0	0	0	33	0	0	0	0	0	32
each stimulator	R	0	100	0	0	33	0	0	0	0	0	32
in each category of report	T	0	0	0	0	33	0	0	0	0	0	36
Total for each category of report		1	1	0	0	3	0	0	0	0	0	22
Percentage of total in each category of report		4	4	0	0	11	0	0	0	0	0	81
Percentage, in	D	11	0	0	0	11	0	0	0	0	0	77
each category, of	R	0	11	0	0	11	0	0	0	0	0	77
the total for each stimulator	T	0	0	0	0	11	0	0	0	0	0	88

TABLE VI—*e*

Showing, for *Th*, a Classification of the 27 Reports, and the Relation of Such Reports to the Stimulators Employed.

Category:	Stimulus	Circle	Ellipse	Semi-Circle	Semi-Ellipse	Crescent	Triangle	Wedge	Rectangle	Diamond	Open Rectil. Fig.	Misc.
Total for each stimulator in each category of report	D	2	3	0	0	0	2	0	2	0	0	0
	R	1	0	0	0	0	1	0	7	0	0	0
	T	3	2	0	0	0	3	0	1	0	0	0
Percentage for each stimulator in each category of report	D	33	60	0	0	0	33	0	20	0	0	0
	R	17	0	0	0	0	17	0	70	0	0	0
	T	50	40	0	0	0	50	0	10	0	0	0
Total for each category of report		6	5	0	0	0	6	0	10	0	0	0
Percentage of total in each category of report		22	18	0	0	0	22	0	37	0	0	0
Percentage, in each category, of the total for each stimulator	D	22	33	0	0	0	22	0	22	0	0	0
	R	11	0	0	0	0	11	0	78	0	0	0
	T	33	22	0	0	0	33	0	11	0	0	0

The tables do not show so striking a massing of reports within single categories as was evident in Experiment 1. In this respect the present *O*s were more like *Ta* in the earlier experiment. Table VI-a *(Br)* shows a general tendency towards circular reports, although far from being the clear-cut preference shown by *Be* in the other experiment. Along with the disks we find ellipses, semi-circles, crescents and other patterns, more difficult to classify; these include some with the general curvilinear character and a number not so classifiable. Table VI-b also shows a large proportion of reports in the Circle and Ellipse categories. The tendency here is quite clear-cut. Table VI-c shows a preponderance in the same categories but the Miscellaneous category is larger. Most of the items within it represent curvilinear patterns. Table VI-e shows a broader distribution of the reports among different categories with the Circle-Ellipse, Triangle and Rectangle most favored. *Th* was the only *O* in Experiment 1 and 2 who concentrated his reports rather evenly in the three correct categories.

Ro's results are worth a separate discussion. It is obvious from VI-d and other tables in this experiment that his results are utterly different from those of the other *O*s. It was the opinion of the experimenter that *Ro* was somewhat less anxious than the other *O*s to 'produce what the experimenter wanted'. The instruction to report shape did not seem to have the same effect on his attitude as was produced in the other seven *O*s mentioned up to this point. It might, perhaps, be fairly said that he tended to be 'negativistic' towards reporting shapes. His comments when given his instructions, although they can not be reproduced here, indicated as much. His report after the third stimulation in the first session was as follows: "I can't possibly draw it: I have no definite impression. I have a mental impression of an egg-shaped thing—a visual image. It probably simply occurred to me because I was looking for a shape—really, I just felt a diffuse warmth sensation." Again, after the sixth trial, *Ro* said, after having reported two or three vague shapes, "I'm not at all sure I'm feeling them—they're really just my interpretation. If I weren't instructed to look for form I'd never in the world recognize it." The experimenter seemed to detect a certain hostility to the instruction. This circumstance provides an interesting check on the suggestion made before that forms were reported because the *O*s readily accepted the experimenter's instruction to look for (and find) forms. In this case, where the instruction was almost deliberately rejected, there was a strong tendency to report *formless* experiences and to give the forms

that were mentioned with apparent reluctance and extremely low certainty.

Since the reports for four of the *Os* did not follow the purely chance distribution of Experiment 1, they were reclassified in term of 'Correct', 'Partially or Possibly Correct' and 'Incorrect or Indefinite'. An example of the first category is a report of a disk or circle of warmth where the D stimulator was used. An example of a 'Possibly Correct' report would be one where an ellipse was reported when the D stimulator was employed. 'Partially Correct' reports would be those where, for instance, a crescent was reported with the D stimulator. These data are shown in Table VII. The number of correct responses varies considerably from one *O* to another. In terms of completely correct responses there is a variation from 4% (one report) for *Ro* to 41% (11 reports) for *Th*. Combining the 'Correct' and 'Partially Correct' categories, *Ro*'s percentage rises to 18 (5 reports) and *Th*'s to 63 (17 reports). The corresponding figures for the other three *Os* lies between these values.

TABLE VII

Showing the Classification of Reports as Correct, Partially Correct and Incorrect (with 'Formless' Reports Considered Incorrect) and the Relationship of Such Reports to the Stimulator Employed.

Observer	Stimulator	Correct No.	Correct %	Partly or Possibly Correct No.	Partly or Possibly Correct %	Incorrect or 'No Form' No.	Incorrect or 'No Form' %
Br	D	2		1		6	
	R	0		3		6	
	T	1		2		6	
	Total	3	11	6	22	18	67
Jo	D	2		4		3	
	R	0		4		5	
	T	1		0		8	
	Total	3	11	8	30	16	59
Me	D	6		2		1	
	R	0		4		5	
	T	1		0		8	
	Total	7	26	6	22	14	52
Ro	D	1		2		6	
	R	0		2		7	
	T	0		0		9	
	Total	1	4	4	14	22	81
Th	D	2		3		4	
	R	6		2		1	
	T	3		1		5	
	Total	11	41	6	22	10	37

To evaluate these data it is necessary to know what *chance* would be. If we assume that the indefinite reports are *wrong*, then 33⅓% is the proportion which might be considered correct by chance. This is considerably complicated, however, by the fact that the *O*s were not restricted in their reports to the three form presented by the stimulators. Under the present conditions the correct figure for chance is less than 33⅓% by an *indefinite* amount. We face the dilemma presented by data which suggest positive results (particularly if the 'partially correct' reports are considered correct) but which cannot be evaluated to determine definitely that this is so.

C. *Accounting for the Forms Reported.*

In the present experiment we have reached the conclusion that forms are reported; that apparently the accuracy of these reports is superior to chance and to the results in Experiment 1. While 'preferences' for specific shapes were less marked than in the earlier experiment, they are present and require explanation. There is considerably more agreement on preferences than was evident with the earlier *Os*. It will be recalled that in the first experiment, one *O* tended to report circles and generally curvilinear figures, the second complete and incomplete triangles, while the third combined the two preferences. Three *O*s in this experiment *(Br, Jo* and *Me)*, showed an unequivocal tendency to report *curvilinear* patterns. *Th*, as mentioned above, through some chance massed his reports among the three correct categories. *Ro*, in the few reports of shapes that he gave, showed a heavy preponderance (90%) of curvilinear patterns. In view of this relative unanimity we may raise the question of 'good form'. In the Introduction we discussed the relationship between 'good form' and what Major terms "ease of cognition', in the tactile modality. The literature showed, in general, that the circle and triangle were 'better' forms. Our data show 13 cases where D was correctly named against 6 each for T and R. If we combine the 'Correct' and 'Partially Correct' categories the totals are 25 for D, 21 for R and 9 for T. The large number of correct reports of rectangles is surprising in the light of the work of Major, Rosenbloom, Zigler and others; and in view of the almost complete absence of such reports in our own Experiment 1. The relatively superior ability to perceive the Disk correctly is in line with expectations. The latter result, and the fact that 63% of all the reports involved curvilinear figures (despite the fact that only one of our stimulators was curvilinear), might be regarded as supporting the Gestalt psychologists' view of 'good form'.

7. *Summary.*

In the present situation, using warm stimuli, forms were perceived, apparently with some relationship to the objective stimulus. In general, accuracy seemed rather poor, but the absence of a measure of chance made it difficult to state how poor or how good. It is not clear whether the slight superiority over the results of the earlier experiment is due to the use of warmth, the enlargement of the rubber disk (reducing confusion from pressure), the increased time of stimulation, or to some unknown factor. There was a clearer tendency in this experiment than before to prefer circular, or generally curvilinear, figures—a result in line with what Gestalt principles would lead us to expect. The almost equally strong tendency to report rectangles correctly is rather surprising from this point of view, and is also out of harmony with the results of experiments in tactual form perception.

Generally speaking, it has been demonstrated that the results in the warm-sense are similar to those in the cold-sense, when the same experimental conditions are employed.

III. Experiment 3.

A. *Procedure.*

In order to set up a situation in which the actual number of correctly reported patterns could be compared with a fixed standard representing chance, a brief series of trials was attempted in which *O* worked with *knowledge of results,* and was aware of the number and nature of the stimulators employed.

One *O*—*Me*—was used in this experiment. He had served also in Experiment 2. He was shown the apparatus (expressing surprise, as all our *O*s have done), and told that his reports were to be limited to the three categories actually used—the Disk, Rectangle and Triangle. After each trial he was told which stimulus had actually been used. In all other respects the apparatus and the entire procedure were identical with those in Experiment 2.

B. *Results.*

In Experiment 2 *Me* had given 7 correct reports, and 6 more which were scored as partially correct; in this experiment, with knowledge, he scored 11 correct. Chance accuracy would have been 9 correct. It is clear that the deviation from chance is too slight to be considered

significant in view of the very small number of trials. It was impossible for *Me* to return and continue the experiment further.

Table VIII shows the distribution of reports in relation to the stimulators employed.

TABLE VIII

Showing, for *Me*, a Classification of the 27 Forms Reported, and the Relation of Such Reports to the Stimulators Employed (with Knowledge).

Category:	Stimulus	Circle	Triangle	Rectangle
Total for each stimulator in each category of report	D	5	1	3
	R	3	5	1
	T	1	5	3
Percentage for each stimulator in each category of report	D	55	9	43
	R	33	45	14
	T	17	45	43
Total for each category of report		9	11	7
Percentage of total in each category of report		33	41	26
Percentage, in each category, of the total for each stimulator	D	55	11	33
	R	33	55	11
	T	11	55	33

It was demonstrated that, since the possibility of form perception in the thermal senses is so tenuous and questionable, a measure for comparison with chance is desirable and useful. Although a trained *O* was used, working with knowledge, accurate form perception was highly questionable. True, there was but one *O*, and a relatively brief series; it was necessary to follow the question further.

IV. Experiment 4.

In view of the fact that the thermal senses are not ordinarily concerned with geometric patterns, perhaps we were forcing a highly unnatural procedure in requiring drawings and verbal descriptions of shapes. Perhaps *discrimination* of forms could be demonstrated where accurate description was impossible. The present experiment was devised to test this possibility.

A. Procedure.

The apparatus, experimental region and general technique were the same as employed in Experiments 2 and 3.

A single *O*, *Th*, was employed in this experiment. He had already served in Experiment 2, and was still in ignorance of the nature of the apparatus and forms used. He was told that the stimuli would be presented in pairs and that in each series one member of each pair would always be the same—the *standard*. The other member of each pair—the *variable*—might be the same as, or different from, the standard and he was to give his report merely as 'Same' or 'Different', omitting all attempts at description.

B. *Results.*

In the first series, where D was the standard, there were 4 correct reports; in the second, with R the standard, 5 correct; and in the third, with T the standard, 7 correct. It is highly unfortunate that it was impossible to keep *Th*'s services longer, in view of the apparent tendency towards greater accuracy. In terms of chance we might expect 4 correct responses in each series of 12 trials. On this basis the actual number of correct is not very promising although the trend is tantalizing. It is to be noted that only 3 of the 16 correct reports were reports where *identity* (report of 'Same') was correctly given.

In view of the small number of trials it is difficult to state definitely whether the change in procedure resulted in superior accuracy. It was decided to continue the use of this method of report. (Experiment 11.)

An interesting side-issue developed from this experiment. Towards the end of the first series *O* spontaneously commented: "The standard doesn't seem to be the same all the way through". At the end of the series he was asked what he thought the standard to be. "I'd say the standard was a disk. It was clearly so when the stimulus was given in the center [toward the midline of the body]. It seemed more like an ellipse when it was at the sides." During the second series, *Th* said: "I'm not very sure of these reports. The stimulus seems to change. [In response to a question.] Reports of 'Same' and 'Different' are of about the same [low] degree of certainty as before." After some urging, at the end of the series, he vouchsafed: "Most of the time the stimulus seemed to be oblong—it seemed to fluctuate more than last time. Sometimes it seemed triangular or linear or oval or square—my best guess would be that it was an oblong." When asked at the end of the third session what the standard was, *Th* replied that he "didn't know". When told to *guess*, he said: "I think it was sort of triangular. I *know* it has an angle in it." It will be seen that in

each case O's final opinion as to the nature of the stimulus, although uncertain, was *completely correct.* In interpreting the results, it would seem that this is a situation where there are vague and unstable experiences. O knew, each time the *standard* was presented, that he was dealing with the *same objective stimulus* and he was able to correct and 'stabilize' his perception. This knowledge was not available in any of the earlier experiments. (But compare Experiment 11.) This is very similar to the situation by which an individual learns to recognize a plate although at one time it may be objectively a narrow ellipse and at another a perfect circle. Perhaps we might say that no such *constancy* has been built up in the thermal modalities. Or, it would be possible to speak of 'trial percepts'; that is, a situation in which, on the basis of meager sensory data (the *sensation* in Woodworth's terms), a tentative perception is built up. In the next trial the percept is somewhat different and on the basis of the knowledge that the same stimulator is involved, the earlier percept is 'corrected'. Analagous is the situation in which long words are presented in indirect vision, or with brief exposure. A word is 'seen', but may be corrected subsequently. These are but possibilities: more can not be said on the basis of so little material.

CHAPTER THREE—EXPERIMENTS WITH RADIANT HEAT PATTERNS

The experiments reported in this chapter are, in the main, outgrowths of the findings and suggestions of the earlier ones. The feature which differentiates them is that the previous apparatus was abandoned and a new principle introduced. In Experiment 2 the size of the hard-rubber disk surrounding the copper forms had been increased because it was felt that the pressure gradient might be close enough to the boundary of the thermal pattern to cause interference and confusion. The results indicated a shade more accuracy than in Experiment 1, but we did not consider them hopeful enough to warrant continuing work under similar conditions. We decided to abolish the pressure factor completely.

After rejecting several designs of apparatus on the basis of preliminary experiments not to be reported here, the new equipment was designed in accordance with the following general principles. Resistance wire was bent into the desired shape and connected in an electrical circuit in which the amount of heat given off by the wire could be controlled. The wire was supported in an apparatus which could be lowered to within a very small distance from the skin surface. While we recognized that the boundaries presented by such a stimulator were not as sharp as in the other set-up, and that radiation would extend to some distance on each side of the wire, we felt that with a very short distance between the stimulator and the skin both these difficulties would be minimized. The essential virtue of the apparatus, of course, was that we could obtain *pure thermal* stimulation. Of equal importance, at least theoretically, was that *outline* figures could be presented. As we pointed out (p. 242) several investigators working with tactual perception found that outline figures were definitely superior to solid ones in ease of perception. It was also felt that under these conditions such principles as the law of Prägnanz could better be studied.

I. Experiment 5.

In order to see just what effect the new apparatus would have, we attempted to keep other conditions as similar as possible to those of Experiments 1 and 2.

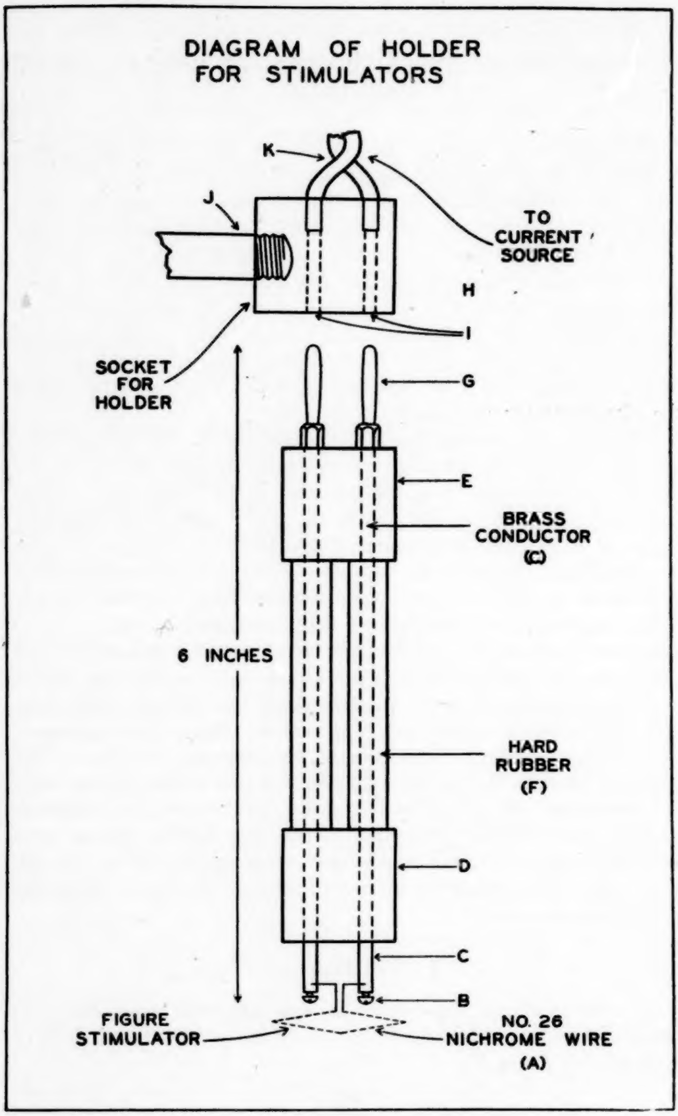
DIAGRAM OF HOLDER
FOR STIMULATORS
K
J
TO
CURRENT
SOURCE
H
I
SOCKET
FOR
HOLDER
G
E
BRASS
CONDUCTOR
(C)
6 INCHES
HARD
RUBBER
(F)
D
C
B
FIGURE
STIMULATOR
NO. 26
NICHROME WIRE
(A)

Fig. 4

A. *Apparatus.*

Figure 4 shows one of the *stimulus-forms* used and one of the three identical *holders*. The bent-wire figure (A), was connected by set-screws (B) to brass conductors (C). These were set in two hard-rubber blocks (D), (E). The portion of the conductors between the blocks was insulated by hard-rubber tubing (F). Inside the upper block (E) the brass conductors were brased to plugs (G). The holder could be inserted by the plugs into the *socket-arm* which consisted of another hard-rubber block (H) with sockets (I) corresponding to the plugs of the holder and of a brass arm (J). Wires (K) led to the terminals of the control-box described in Figure 5.

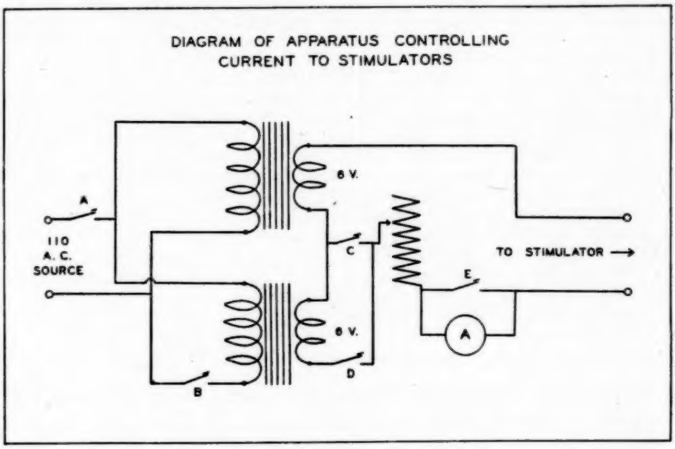

Fig. 5

Figure 5 shows the wiring diagram for the apparatus controlling the current to the wire figures. Varying the amperage varied the amount of heat given off. From the 110 A.C. source the current was led to one or two transformers. These were No. 5510 transformers (in the Wholesale Radio Service Co. catalogue), each 115 v. on the 'high' side, connected in parallel, and 10 v. on the 'low' side, connected in series. The center-tap was not used. Setting the switches (A), (B), determined whether the current flowed to one or both transformers. From the transformers the current was directed to a 'Vitrohm' field rheostat (No. 60-3098 in the Ward Leonard catalogue), rated at 10 ohms, 11-3.1 amps. From the rheostat wires led to outlet terminals. The amperage was read directly from the Weston (Model 429) 10 amp., A. C. ammeter which could be thrown into the circuit by the switch (E). The switches (C), (D), set the circuit on the 'low' side so that one or both of the transformers could be used. The apparatus was rarely used above 2 amps. but this was not known in advance and 12 amps. were provided for.

The figures used were a Circle (C), Square (S) and Triangle (T).

The holder was mounted in a universal support by means of which it could be raised and lowered and placed in position over the desired portion of the stimulus region, with 1-2 mm. from the skin as the ideal distance.

Patterns can be equated in a number of different ways but, obviously, cannot be equated in all of them at the same time. In the earlier experiments it was deemed that equation in terms of the *main dimension* was to be preferred to the commonly used equation in area. In the present experiment, the forms were equated in *perimeter*. The determining reason was that once the rheostat was set at a given value, changing from one stimulator to another could be performed without altering the amperage, since the length of the wire through which the current passed (and, therefore, the resistance) remained the same.

The amount of heat given off by the resistance wire that constitutes the stimulator, is, of course, a function of the amperage it is carrying. To measure it directly would have required a form of thermocouple, but since the effect of radiant heat is cumulative in its physiological effect [40, p. 232, footnote], such a measurement would have been of little significance to us. In order to know just what *effect* the stimulus was having—which was our real concern—we decided to depend on the *O*'s report. As will be seen below, he was instructed to report 'warmth' and 'heat': the time between these two reports we took as the measure of duration of the *effective stimulus*. Preliminary trials enabled us to fix the limits of the current used between 1.6 and 2.1 amps. The variation was due to the differing sensitivity of the *O*s. The intensity was such that the effective stimulus duration was between (roughly) 5 and 15 seconds. The stimulator was generally maintained at a distance of 1-2 mm. from the skin.

The perimeter of each stimulator was 3 in. and the total length of the wire (including the portions serving as leads) was 4 in.

See also Section III, D of Chapter Five.[1]

B. *Experimental Region.*

Preliminary experiments showed that there would be great difficulties in using the same regions as before, the chest and abdomen. The greatest obstacle was breathing movements, presenting the constant danger of branding *O* by direct contact with the stimulus, and the additional difficulty that a constant distance could not be maintained between the stimulus and the skin surface. For this reason we used the back of the forearm and hand. This region afforded a relatively homogeneous area and considerable stability. The arm was supported in a wooden rest which was filled with cotton. This was almost as comfortable and steady a rest as a plaster-cast and obviated the necessity of making a cast for each *O*.

The forearm was divided roughly into quarters from the elbow to the wrist, numbered in that order Areas 1-4; the back of the hand

[1] Despite certain obvious physical limitations of the apparatus, it was felt that at the present stage of our knowledge in this field, and in view of our ignorance of even such elementary facts as the nature, size and location of the end organs for warm and cold sensitivity, it was unnecessary to *over*-refine the physical stimulus conditions.

from the wrist to the knuckles was divided into two regions, one between the thumb and the middle phalanx, numbered Area 5, and one from the phalanx to the outside margin of the hand, called Area 6. The areas on both arms were used in rotation; the same portion of an area was never used twice the same day. The surface was shaved regularly to avoid contact with the stimulator and the resulting experiences of pressure. *O* was asked to do this at home in order to avoid rawness which might be present if we did the shaving just before stimulation.

After the area to be used had been determined, the size of the forms was fixed.

C. *Procedure.*

O was seated at a table on which was placed the universal support holding the stimulator. Several layers of black cloth hanging before the table screened his vision from the apparatus and the experimental surface. The experimenter lowered the stimulator so that the wire figure was 1-2 mm. from the skin. Considerable difficulty was encountered in placing the figure so that it was equidistant from the arm at all points. It is practically impossible to find a plane surface, even of the dimensions we required, anywhere on the surface of the arm. It was necessary to adjust the apparatus each time until we could secure the 'best fit'. We wish to emphasize this difficulty here. Undoubtedly, as a result of it, portions of the warmth-pattern were sensed before others: it was not a simultaneous presentation such as can be achieved visually. There is no way of telling how, and to what extent, this differential time factor distorted the objective image of the pattern. Further, since the arm is a curved, rather than a plane surface, the image is distorted again. We were able only to minimize, not to overcome this extremely serious difficulty.

After the stimulus was lowered into place, a 'Ready' signal was given and the current switched on. *O* was required to say 'Warm' as soon as warmth was felt and 'Hot' when the stage of non-painful heat was attained. All *O*s quickly learned to distinguish warmth, heat and painful heat. At the report 'Hot' the current was turned off, the stimulus removed and *O* gave his report, following which the next stimulus was presented in the same way. The number of trials in each experimental session varied somewhat, depending on *O*'s familiarity with the procedure, length of his reports, *etc.* In the present experiments it was 6 or 9. The number of sessions varied, unfortunately, with the time the *O* had available.

D. *Instructions.*

Since our purpose was to determine whether changing apparatus really created a new situation, the instructions were much as in Experiment 1 and 2. *O* was told (after he had been seated and his arm placed in the support):

"You are to hold your arm still until I tell you that it is safe to move it. After a 'Ready, Now' signal you will feel warmth. You are to say 'Warm' when you feel warmth and 'Hot' when you feel heat. When the apparatus is removed you are to describe the experience as fully as possible, and in detail. Describe your *experience*—don't guess about the stimulus."

No drawing was required, as it had been found in the preceding experiments that it added nothing to the verbal report except in unusual cases. The experimenter felt free further to question *O*. Some of the questions may be regarded at 'leading'; *e.g.*, in the first session with one *O*, the experimenter asked the following direct questions:

"Did it feel the same all the time between your reports of 'Warm' and 'Heat'?"

"How large was it?"

"Was it of the same intensity over the entire warm area?"

"Can you say anything about its shape?"

After the first few trials very few questions were asked; the purpose of them was to indicate to the *O* that a full report was desired. Questions were also asked on points which were irrelevant to the main purpose of the study so that the 'leading' quality of the questions would not be too great.

E. *Observers.*

In this experiment two *O*s served, beginning students in psychology at Brooklyn College Summer Session. They were designated as *Ei* and *Pr*. The experiments were carried on during August and September, 1936.

F. *Results.*

Tables IX-a and IX-b indicate the number of trials in which no forms could be described and the accuracy of the reports where forms were given.

TABLE IX

Showing the Classification of Reports Where Form Was Correct, Partially Correct, Incorrect or Absent.

Ei

Total number of reports: 51

	Form Absent	Form Correct	Form Correct, Incomplete	Form Partly Correct, Partly Incorrect	Two Possibilities Reported: One Correct	Form Incorrect
Number	15	4	6	1	2	23
Percentage of total	29	8	12	2	4	45
Percentage correct and partially correct omitting 'Form Absent' from the base.			36			

Pr.

Total number of reports: 32

	Form Absent	Form Correct	Form Correct, Incomplete	Form Partly Correct, Partly Incorrect	Two Possibilities Reported: One Correct	Form Incorrect
Number	15	2	2	1	0	12
Percentage of total	47	6	6	3	0	38
Percentage correct and partially correct omitting 'Form Absent' from the base.			30			

The experimenter was now aware of the influence of the suggestion to report shape and was somewhat more cautious in the instructions; apparently this was effective in reducing the *number of patterns reported* as compared with the earlier experiments. 47% of *Pr*'s and 29% of *Ei*'s were in the 'Form Absent' (absolutely formless) column. Where forms were reported, their accuracy was obviously and markedly low. Considering the 'Form Correct' column we find but 8% and 6% correct for *Ei* and *Pr* respectively. If we add to this category all the reports that were partially correct in some respect, the percentage rises only to 26% and 15%. For comparison with the results of the earlier experiments, where the corresponding percentages were computed on the basis only of reports where shapes were given (rather

than all the reports, as here), the percentage would rise to 36% and 30%.

We may conclude, then, that *the use of radiant stimulation* (using the same size stimuli as before; with the added difficulties arising from the contour of the arm) *yields approximately the same* (low) *degree of accuracy as before*. The data on the *nature* of the forms reported have not been presented here: they add nothing essentially new to what was determined in earlier experiments. Our main problem was to see whether under the new stimulus-conditions more accurate perceptions would be reported than before. The answer was in the negative. Even with two *Os*, marked individual differences are clearly noticeable.

II. Experiment 6.

The present experiment was devised for comparison with Experiment 3 (see p. 275). The procedure was exactly the same, knowledge of results and of the nature of the stimulus were provided; the apparatus was that of Experiment 5, that is, using radiant heat. *O* was *Pr*, who served in the last expeirment.

Table X, using the same categories as Table IX, presents the results in this experiment. Despite the new instructions *Pr* refused to confine his reports in such a way that they could be scored in the 'Form Correct' and 'Form Incorrect' columns. Of the 32 trials there were 4 in which he could not report a pattern; 1 in which his response was partially correct ("I'm sure there is an angle there—I don't know whether it's the triangle or not.") and 7 reports in which he could

TABLE X

Showing, for *Pr*, the Classification of Reports Where Form Was Correct, Partially Correct, Incorrect or Absent When *Pr* Had Complete Knowledge of Set-Up and Results.

Total number of reports: 32

	Form Absent	Form Correct	Form Correct, Incomplete	Form Partly Correct, Partly Incorrect	Two Possibilities Reported: One Correct	Form Incorrect
Number	4	1	1	0	7	19
Percentage of total	13	3	3	0	22	59
Percentage correct and partially correct omitting 'Form Absent' from the base.			32			

only state that the pattern was one of two possibilities. The amazing fact is that but one reported pattern was correct while 19 were incorrect. This is far below chance expectation.

Little more can be said with so little to go on, and an elaborate discussion is not justified.

III. Experiment 7.

In view of the failure of the radiant stimulus to produce more definite and reliable patterns than the earlier type of stimulus, it was decided that it was time to determine precisely the *effect of the instruction* to report form, a factor which was felt to be of great importance even in dealing with the results of the very first experiment.

A. *Apparatus.*

The structural characteristics of the apparatus used were the same as in Experiment 5. At first the T stimulus only was used. Even though the reports might be vague at first it was hoped that some 'learning' might occur if the same stimulator were used (without the *O*'s knowledge). After a few trials the T stimulator was abandoned and a new stimulator, a straight line (L) 1 in. long, was substituted. This offered greater ease in placement of the stimulus in conformity with the contours of the arm and had the added advantage of being a simpler form.

B. *Experimental Region.*

The *Os*' arms were used as described in Experiment 5. The same 'Areas' were used.

C. *Procedure.*

In general, the procedure was as in Experiment 5. The essential difference was in the instructions (see below).

D. *Instructions.*

After *O* was seated and his arm properly placed, he was told:

> "A few moments after the 'Ready, Now' signal you will feel warmth on the indicated area of your arm. Report when you feel warmth and when you feel heat—as signals for me. You will then report your experience as fully as possible, with no prompting on my part. Try to include *everything* in the way of description, no matter how obvious or how silly it may appear."

These instructions were designed in the hope that they would elicit full reports, including reports of shape if experiences of shape

were actually present, and *only* in those cases. No further instructions were given at any time, except that *O* was occasionally reminded to make full reports if they seemed to be becoming stereotyped. The experimenter limited his questions to "What else?" if *O* paused in his report without explicitly stating that he had completed it.

E. Observers.

Os were *Brg*, a beginning student in Psychology in Columbia College and *Mo*, a graduate student in Chemistry with no training in Psychology, whose services were available through the N.Y.A. The experiments with *Mo* were carried on from October to December, 1936; in December, 1936 with *Brg*. The data for *Mo* are more extensive because of the greater time he had available and because *Brg*'s were taken as a check on the former.

F. Results.

1. *Are Patterns Perceived?*

Of *Mo*'s 135 reports secured under the conditions outlined above, there was no mention of pattern in 110 cases. Of the remaining 25 trials none was correct, 2 were partially correct and 23 were incorrect. *Brg*'s 120 reports were scored as 1 correct, 4 partially correct, 1 incorrect and 114 with no reports of form. This is almost overwhelming evidence that forms will not usually be reported unless specifically called for. The data are presented in Tables XI—a and XI—b.

Mo showed a somewhat greater tendency than *Brg* to report patterns. Of 12 sessions there were only two in which he reported no shapes: the 7th and the 12th. The largest number of shapes (6—all incorrect) was reported in the 4th session and the next largest number (4) in the 8th session. Thus there is no tendency for more patterns to be reported with additional *experience* in this rather novel situation. It is rather striking that in all of our experiments the trend of any *O*'s data is as manifest in any single session as in the total series. The shape was *never* reported as the most striking or impressive characteristic experienced. Thus, in the last trial of the first session, *Mo* gave the following statement only after he had been prompted to go on three times: "[Long pause] The sensation felt as though it was a circle of warm. Not empty—but in a circular *area*." He then went on to report other characteristics of the experience. This was typical. The stimulus, incidentally, was T.

TABLE XI

Showing the Classification of Reports Where Form Was Correct, Partially Correct, Incorrect or Absent.

Brg

Total number of reports: 120

	Form Absent	Form Correct	Form Correct, Incomplete	Form Partly Correct, Partly Incorrect	Two Possibilities Reported: One Correct	Form Incorrect
Number	114	1	0	0	4	1
Percentage of total	95	.8	0	0	3.4	.8
Percentage correct and partially correct omitting 'Form Absent' from the base.			83			

Mo

Total number of reports: 135

	Form Absent	Form Correct	Form Correct, Incomplete	Form Partly Correct, Partly Incorrect	Two Possibilities Reported: One Correct	Form Incorrect
Number	110	0	2	0	0	23
Percentage of total	81.5	0	1.5	0	0	17
Percentage correct and partially correct omitting 'Form Absent' from the base.			92			

Brg reported shapes in the 1st, 2nd, 4th and 5th sessions. The following statement was considered 'Correct': "Sort of a strip [draws fingers along arm indicating a line]". The stimulator was L. Despite the experimenter's urging to give complete reports, and even such a statement as "Most of your description has been qualitative and quantitative—in terms of intensity of warmth—you needn't limit yourself to this", *Brg* very soon reached a degree of stereotypy not encountered with any other *O*. Typical of his reports is the following: "It started out warm, then a slight tickling. The warmth gradually increased, accompanied by a prickly sensation, and went on to heat. That's all.", or: "Warm; increased gradually to heat with no accompanying sensation. That's all there was to it."

2. *'Stages' in Form Perception.*

Differences between *Os* in terms of the content of their reports have been noted here and in the preceding experiments. The difference between *Mo* and *Brg* was such that they might almost be dealing with different material. Examination of the data suggested that there might be a continuous gradation from reports concerned merely with the quality of sensations and their relative intensity (almost 'Titchenerian' introspection) through reports which include descriptions of localization, size, and distribution of intensity within the area, to reporting shape—and, at the extreme, sharply bounded shapes. An analysis such as that in Tables III-a, III-b and III-c crudely presents part of this phenomenon of variation from 'formless' to 'formed'. We decided to draw up a tentative series of steps between quality-quantity reports and bounded-shape reports. Tables XII-a and XII-b contains the data so classified. The first category indicates the presence of *qualitative* and *quantitative* description of the experience whether or not there were other types of description. The next, deals with *localization* and it, too, may be combined with other categories of description. Reports in which the warm region is described in terms of the skin surface and 'landmarks' are included here. Size—is another category which is not exclusive. All cases in which *size* was estimated belong here. *Differentiation* indicates description in which the warm experience is *spatially* broken up into portions of varying intensity, clearness or, sometimes, quality. *Vague, unbounded shapes* are represented by the next category. Here we might have such a

TABLE XII—a

Showing, for *Brg*, the Number of Reports Falling Into Each 'Stage' Between Reports of Simple Quality and Intensity to Clear Bounded Patterns, When the Instructions Do Not Specify the Terms of Description.

Total number of trials: 120

Reports included remarks on:	Number	Percentage
Quality and intensity	120	100
Localization	4	3
Size	7	6
Differentiation within warm area	8	7
Shape vague or unbounded	6	5
Differentiation within warm area and part of it bounded	0	0
Partly or indefinitely shaped	0	0
Clear definite shape	3	3
Orientation of warmth, dimensions in relation to bodily axes	0	0

TABLE XII—b

Showing, for Mo, the Number of Reports Falling Into Each 'Stage' Between Reports of Simple Quality and Intensity to Clear Bounded Patterns, When the Instructions Do Not Specify the Terms of Description.

Total number of reports: 135

Reports included remarks on:	Number	Percentage
Quality and intensity	135	100
Localization	58	43
Size	60	44
Differentiation within warm area	62	46
Differentiation within warm area and portion of it bounded	0	0
Shape vague or unbounded	23	17
Partly or indefinitely shaped	0	0
Clear definite shape	0	0
Orientation of warmth dimensions in relation to bodily axes	0	0

report as: "Diffuse warmth—sort of circular—no boundary that I could feel, just faded off into nothing." The next step means that the vague, uncertain shape is either partly or quite vaguely bounded while the final step includes the clear and definite forms, usually well bounded.

Such a series of steps or stages 'leading up to' the perception of form implies certain theoretical concepts which we propose to discuss at length in Chapter IV. Theory aside, it is quite possible to question the precise categories employed and their order. Let it suffice to admit that such a presentation is crude and arbitrary but that it seems to yield useful data of some theoretical importance, as will be seen.

3. *A Word on Individual Differences.*

Tables XII-a and XII-b might be called 'profiles' of the terms in which the *Os* reported. The simple fact that *Mo* was somewhat discursive, while *Brg* definitely felt he had completed his task after the type of description we have quoted accounts in part for the emphatic differences. But apparently we are dealing here with a real difference in attitude, if not a genuine difference in personality. In all the experiments presented thus far there have been such extreme differences between our *Os* in the type of form reported, the nature of the reports, the characteristics emphasized, *etc.*, that it has been extremely tempting to bring in the question of personality. Let us merely state here that if the investigation had taken a slightly different turn it might well have become a study of personality dif-

ferences. We might point out, *e.g.*, that *Brg*, who is studying engineering, gave the type of report one might expect from an engineer, using quantitative terms whenever possible and describing changes in quality and intensity as though he were looking at a graph. It has occurred to the experimenter that there is almost enough material here for a 'thermal Rorschach test'. The principle of a labile situation, in which the *O supplies* most of the content is similar.

If we glance at the tables we may see how little tendency there was to report patterning when not specifically demanded by the instructions. For purposes of comparison, similar tables (Tables XIII-a and XIII-b) were drawn up from the data available for *Ei* and *Pr* working under the instruction described in Experiment 5.

The difference between the 'formed' and 'unformed' halves of the tables is still evident but less prominent. This comparison is, however, not so suggestive of the effect of the instruction as might have been expected from what has gone before. We felt that this might be because the instructions to *Ei* and *Pr* had not so definitely demanded reports of pattern as was the case in some of the earlier experiments, such as Experiment 1. For this reason Experiment 8 was conducted.

TABLE XIII—a

Showing, for *Ei*, the Number of Reports Falling Into Each 'Stage' Between Reports of Simple Quality and Intensity to Clear Bounded Patterns When the Instructions Suggest Description in Terms of Shape.

Total number of trials: 51

Reports included remarks on:	Number	Percentage
Quality and intensity	51	100
Localization	31	61
Size	42	82
Differentiation within warm area	2	4
Differentiation within warm area and portion of it bounded	4	8
Shape vague or unbounded	8	16
Partly or indefinitely shaped	17	33
Clear definite shape	3	6
Orientation of warmth dimensions in relation to bodily axes	4	8

TABLE XIII—b

Showing, for *Pr*, the Number of Reports Falling Into Each 'Stage' Between Reports of Simple Quality and Intensity to Clear Bounded Patterns When the Instructions Suggest Description in Terms of Shape.

Total number of trials: 32

Reports included remarks on:	Number	Percentage
Quality and intensity	32	100
Localization	7	22
Size	20	63
Differentiation within warm area	2	6
Differentiation within warm area and portion of it bounded	0	0
Shape vague or unbounded	10	31
Partly or indefinitely shaped	7	22
Clear definite shape	0	0
Orientation of warmth dimensions in relation to bodily axes	4	13

IV. Experiment 8.

This experiment was introduced for the express purpose of presenting instructions *requiring* descriptions in terms of shape, as in Experiment 1. *O* worked without knowledge because we wished him to give a general description of his experience and not merely to report in terms of fixed categories. It was necessary to use, otherwise, the same general apparatus and procedure as in Experiment 7 since we wished to make a direct comparison between the results of the two experiments.

A. *Procedure and Instructions.*

The experiment differed from the preceding one only in the instructions, which were as follows:

"A few moments after a 'Ready, Now' signal you will feel warmth on your arm. You are to report when you first feel warmth and when heat. I want you to determine the *shape* of the warmth. You may report each time. Don't guess at the *object*—it's your *experience* that is of interest. However, you may be told that the stimulus is always the same—perhaps varying in its position. It may be any shape at all."

The L stimulator was used.

O was *Ka*, a Columbia College Junior with no psychological training, whose services were obtained through the N.Y.A.

The experiment was conducted in October and November, 1936.

B. *Results.*

1. *Accuracy of Form Perception.*

We may turn, first, to the data on *Ka*'s accuracy in Table XIV. The instructions were effective, in that *no* reports were given which could not be scored in terms of patterns. However, there was but 1 *completely correct* report, 77 *incorrect* and 60 which were scored *partially correct*. The comparatively large number of partially correct items is to be attributed to rather easy scoring. *Ka*'s reports were difficult in the extreme to score in terms of accuracy. More than any other *O* he avoided the customary geometrical forms and their modifications. He tended to report what can only be described as 'fantastic' forms from time to time. "Wavy lines", "shrubs", "crossing lines", "pear-shaped objects", etc., were among his descriptions. It is possible to understand this in terms of a strong set to report patterns but the absence of any *Einstellung* towards any *familiar* form (see p. 259).

TABLE XIV

Showing, for *Ka*, the Classification of Reports Where Form Was Correct, Partially Correct, Incorrect or Absent.
Total number of reports: 138

	Form Absent	Form Correct	Form Correct, Incomplete	Form Partly Correct, Partly Incorrect	Two Possibilities Reported: One Correct	Form Incorrect
Number	0	1	11	29	8	89
Percentage of total	0	1	8	21	6	64
Percentage correct and partially correct				36		

2. *Nature of Results.*

Turning to the data to obtain which the experiment was specifically devised, we find in Table XV that *Ka*'s results differ markedly from the results of *Brg* and *Mo* in Experiment 7 and differ in the expected direction. *Quality* and *intensity* descriptions of the sensations of warmth, heat, etc., disappear completely (except in the reports of 'Warm' and 'Hot' by which the timing of the stimulation was controlled). In almost every case an estimate of the *size* is given—this may be considered an individual characteristic. Some comment on *localization* was offered in 23 cases. In every case *forms* were described, most of the time falling in the 'Form Vaguely Bounded' category. The 'profiles' in the two experiments are very different.

TABLE XV

Showing, for *Ka*, the Number of Reports Falling Into Each 'Stage' Between Reports of Simple Quantity and Intensity to Clear Bounded Patterns When the Instructions Specifically Reqquire Reports of Shape.
Total number of trials: 144

Reports included remarks on:	Number	Percentage
Quality and intensity	0	0
Localization	23	16
Size	130	90
Differentiation within warm area	0	0
Differentiation within warm area and portion of it bounded	0	0
Shape vague or unbounded	18	13
Partly or indefinitely shaped	110	76
Clear and definite shape	18	13
Orientation of warmth dimensions in relation to bodily axes	3	2

It can be seen now, also, that those for *Pr* and *Ei* fall midway between the extreme cases represented by Experiments 7 and 8.

We have sufficient evidence now to state with assurance that *the proportion of patterns reported* under the same stimulus conditions *is largely* (may vary from 7% to 100%) *dependent on the instructions given.* It is doubtful whether the low percentage mentioned would occur in a situation where *visual* forms were presented even under the conditions of 'free report' that existed in Experiment 7. This tends to confirm the hypothesis offered in connection with Experiment 1 and later experiments, that a high proportion of patterns was due to an *induced set for shape* in the *O*. This, in conjunction with the extremely low degree of accuracy that was evident through all these experiments, leads forcefully to a *negative conclusion on the presence of form perception in the thermal modalities.* However, we are restrained from such a conclusion because under conditions where forms were *not* suggested, reports of patterning, however few in number, were obtained. More compelling is the possibility that the *apparatus used was inadequate* in terms of size, sharp definition, variety of pattern or some other characteristic, to demonstrate the presence of this type of perception. However, the problem has been advanced to the point where we can definitely conclude that *under the present conditions* thermal form perception can not be successfully demonstrated.

CHAPTER FOUR—'SIMPLIFICATION' EXPERIMENTS.

I. Experiment 9.

In view of the conclusion to the series of experiments reported in the last chapter, it was necessary to set up a situation eliminating some of the earlier difficulties. Working on the assumption that form perception was possible but that our apparatus and technique had not been adequate for its demonstration, we considered the factors which might be responsible. One which caused considerable annoyance was the difficulty of adequately adjusting the *distance between the stimulator and the skin surface*. Even using stimulators as small as were employed in all the experiments of Chapter Three, it was rarely possible to maintain an equal distance between all parts of the stimulus and the skin below. It had been found that when the L stimulator was employed considerably less trouble was encountered.

We wished, also, to *simplify* the situation. We felt that requiring descriptions or even discrimination of three visually simple patterns might not really be a simple task in the thermal modalities. This is the more likely to be true if we bear in mind that topologically the three figures are rather similar. Following this line of reasoning, we determined to use only the *line* (a very narrow rectangle in terms of the pattern on the skin) as the stimulator and to require discrimination merely of its *orientation*, that is, the *direction* in which it lay.

A. *Apparatus.*

The apparatus used here consisted again of the radiant heat set-up, and the L stimulator. For convenience in applying the stimulator a second L stimulator was constructed in which the line ran at right angles to the plane formed by the two conductors of the holder (see Figure 4). With this it was possible to change the direction of the line in relation to the arm faster than if the universal support had to be completely readjusted.

B. *Experimental Region.*

The forearm and hand, subdivided as in the preceding experiments, were used again. The stimulus 'Along' (see below) was always

placed *parallel* to the long axis of the arm and the stimulus 'Across' was placed at *right angles* to it.

C. *Procedure.*

The purpose of the experiment was to determine whether *O* could discriminate between a line of warmth 1-inch long when it was at right angles to the axis of his arm and when it was parallel to it. (A 3-inch line had been used in preliminary experiments, but it was found to be too difficult to adjust to contour variations. *O* was not told in this experiment precisely what the direction of the line might be but was required to report its direction. The 'Across' and 'Along' directions of the stimulators were varied systematically.

D. *Instructions.*

Instructions were as follows:

"A few moments after the 'Ready, Now' signal you will feel a *line* of warmth on your arm. Report when you feel warmth and when you feel heat. After the stimulus is removed, you are to report the *direction* of the line and, in addition, anything else you notice—such as length, location, intensity, *etc.* The stimulus will remain the same except for its direction and location on your arm."

E. *Observers.*

The *O*s in this experiment, whose time was made available by the N.Y.A., were *Mo* (see Experiment 7) and *Di*, a first year student in Psychology at Columbia College. *Mo*, of course, had previously worked under different conditions, *Di* was new to the situation. Both worked without knowledge of the nature of the stimuli. There were 10 sessions with each *O*.

F. *Results.*

Tables XVI-a and XVI-b show the results for 180 trials for *Mo* and *Di*. The reports were classified in three categories: 'Correct', 'Incorrect' and 'Uncertain'. From the tables it is obvious that there was no significant gain over chance. If we omit the 'Uncertain' responses, 37% of *Mo*'s reports are correct. This is markedly *below* chance and it is difficult to explain why this should be. *Di*'s accuracy was 56%. Thus, despite the attempt to simplify the situation by requiring reports only of directions, negative results still prevail. It is interesting that the *O*s were fairly confident of their responses.

We hoped that although the experiment failed to yield positive results we might obtain illumination on some of the disturbing factors.

One of these might be a *systematic* distortion, much as in the tactual modalities where the two-point limen on the arm varies depending on whether the points are placed paralled or at right angles to the long axis. (See *Th*'s report, p. 277.) With this in mind we proceeded to analyze the results where the stimulator had been 'Along'

TABLE XVI—a

Showing, for *Di*, the Classification of His Reports as 'Correct,' 'Incorrect' and 'Uncertain'

	—Number—		
Session	Correct	Uncertain	Incorrect
I	8	3	7
II	5	6	7
III	12	2	4
IV	6	3	9
V	10	0	8
VI	8	2	8
VII	11	3	4
VIII	11	2	5
IX	4	8	6
X	9	0	9
Total	84	29	67
Percentage	47	16	37
Percentage omitting 'Uncertain' from the base	56		44

TABLE XVI—b

Showing, for *Mo*, the Classification of His Reports as 'Correct,' 'Incorrect' and 'Uncertain'

	—Number—		
Session	Correct	Uncertain	Incorrect
I	9	1	8
II	5	0	13
III	6	3	9
IV	6	1	11
V	5	0	13
VI	7	0	11
VII	7	2	9
VIII	3	2	13
IX	8	2	8
X	6	1	11
Total	62	12	106
Percentage	34	7	59
Percentage omitting 'Uncertain' from the base	37		63

and those where it had been 'Across', for systematic distortion of the type mentioned would result in greater accuracy in one or the other situation, or in a preponderance of reports of 'Along' or 'Across'.

Tables XVII-a and XVII-b, however, show that the results broken down in this fashion are almost precisely the same as when they were lumped together. Thermal perception, then, in the simplified terms here required, is no more accurate than when description of forms was involved, nor is there any evidence of a systematic influence disturbing the perceptions.

In the rather long series involved, there was no suggestion of improvement. This was also true, it will be remembered, in the earlier experiments. Yet we are justified in expecting perceptual learning, even without supplying knowledge of results or other external cues, unless there were *no* objective basis for it at all. This is shown by related experiments in vision dealing with both meaningful and meaningless material [14, 17, 39].

Although the possibility remained that our stimulators were too small, or inadequate in some other way, we determined, because of the difficulties connected with altering the apparatus (body contours, movements of the larger surfaces of the body, elimination of pressure, etc.), to ascertain whether a situation retaining it, but specifically encouraging learning would result in scores significantly above chance.

TABLE XVII

Showing the Classification of Reports as 'Correct,' 'Incorrect' and 'Uncertain,' Considering Separately, the Cases Where the Stimulus Was 'Along' and 'Across' O's Arm.

a—*Di*

	'Stimulus Along'		
	Correct	Uncertain	Incorrect
Number	42	17	31
Percentage	47	19	34
	'Stimulus Across'		
Number	42	12	36
Percentage	47	13	40
Total	84	29	67

b—*Mo*

	Correct	Uncertain	Incorrect
'Stimulus Along'			
Number	30	5	55
Percentage	33	6	61
'Stimulus Across'			
Number	32	7	51
Percentage	35	8	57
Total	62	12	106

II. Experiment 10.

Our purpose here was to exhaust the possibilities of the apparatus we have described in the preceding experiments. An effort was made to weight all possible factors, except actually seeing and handling the stimulators, in favor of the *O*.

A. *Procedure.*

The general technique was much as described in the last experiment, but its essence lies in the modifications reported below (see instructions). The *O*s were the same and by this time could be considered *trained observers*. This experiment was carried out immediately after the completion of Experiment 9.

B. *Instructions.*

The *O*s were told that a new experiment was beginning, and instructed as follows:

"A few moments after the 'Ready, Now' signal, you will feel a line of warmth on your arm. Report when you feel warmth and when you feel heat. After the stimulation you are to report the *direction* of the line: that is, whether it was *across* or *along* your *arm*. After the stimulus is removed and you have given your report you will be told, in each case, the *actual* direction of the line."

After a few series, *O* was offered a *reward* for each correct report over chance. While the order of presentation of the two stimuli was varied and unpredictable, it is obvious that the situation favored results beyond chance expectancy, and deliberately omitted some of the precautions which would be included in most learning experiments.

C. *Results.*

1. *Accuracy of Form Perception.*

In spite of this weighting of the situation, Tables XVIII-a and -b and XIX-a and -b show almost the same results as were obtained

in the preceding experiment. Apparently the only effect of the knowledge of results and the other incentives used, was to reduce and almost eliminate the 'Uncertain' reports; *Mo*'s accuracy remained slightly poorer than chance and *Di*'s very slightly better. There is no reason at all for believing that we have here anything other than a chance result.

2. *The Effect of the Learning Situation.*

It will be seen that *Mo*'s table includes 10 sessions and shows a fairly consistent level of response. *Di*'s, on the other hand, shows better than chance accuracy appearing rather suddenly at the 9th session and continuing to the 10th. For this reason we continued the experiment with this *O* (eighteen sessions instead of ten) and at-

TABLE XVIII—a

Showing, for *Di*, the Classification of His Reports as 'Correct,' 'Incorrect,' and 'Uncertain,' Where He Had Knowledge

Series	Correct	—Number— Uncertain	Incorrect
I	9	2	7
II	14	1	3
III	7	3	8
IV	9	3	6
V	10	2	6
VI	7	0	11
VII	9	0	9
VIII	9	0	9
IX	13	0	5
X	12	0	6
XI	12	1	5
XII	10	0	8
XIII	12	0	6
XIV	8	1	9
XV	10	0	8
XVI	9	0	9
XVII	8	0	10
XVIII	11	0	7
Total	179	13	132
Percentage	55	4	41
Percentage omitting 'Uncertain' from the base	58		42

TABLE XVIII—b

Showing, for *Mo*, the Classification of His Reports as 'Correct,' 'Incorrect' and 'Uncertain,' Where He Had Knowledge

Series	Correct	—Number— Uncertain	Incorrect
I	6	0	12
II	10	0	8
III	7	0	11
IV	7	0	11
V	7	0	11
VI	10	0	8
VII	9	0	9
VIII	8	0	10
IX	8	0	10
X	6	1	11
Total	78	1	101
Percentage	43	1	56
Percentage omitting 'Uncertain' from the base	44		56

TABLE XIX

Showing the Classification of Reports as 'Correct,' 'Incorrect' and 'Uncertain,' Considering Separately the Cases Where the Stimulus Was 'Along' and 'Across' *O*'s Arm Where *O* Had Knowledge

a—*Di*

	Correct	Uncertain	Incorrect
'Stimulus Along'			
Number	94	7	61
Percentage	58	4	38
'Stimulus Across'			
Number	85	6	71
Percentage	52	4	44
Total	179	13	132

b—*Mo*

	Correct	Uncertain	Incorrect
'Stimulus Along'			
Number	35	1	54
Percentage	39	1	60
'Stimulus Across'			
Number	43	0	47
Percentage	48	0	52
Total	78	1	101

tempted to discover, at the same time, the basis for his improvement. *Di* himself ventured this explanation (during a rest period half way through the tenth session): "When it definitely felt as though it were

across, I called it 'Across'. When I felt just a point, or a line which was at an angle, I called it 'Along'. It was very rarely that it was felt clearly as 'Along'. 'Across' was felt more clearly more often." The experimenter questioned him about the experiences of a 'point'. *O* said: "I don't know the size of the point. It seems to be like a sort of pin-point." *Di* reported that this 'system' had been adopted during the preceding series (where the improvement had commenced) and thought that the superior results was due to its use. Previously when he had felt a point, *e.g.*, he had "tried to get a visual image which would *make* it one or the other. But I sometimes had to guess or call it doubtful." [1] This was very promising in that it suggested the actual occurrence of a sort of systematic distortion such as we had sought in the last experiment. However, after a few more sessions *Di*'s new accuracy (which had been winning him rewards consistently) disappeared, and he returned to a chance level and remained there despite an increase in the amount of the reward offered. Apparently *O* had not simply lost sight of the technique he had devised for dealing with doubtful cases since he commented on the fact that "It didn't seem to be working right." Because of this return to the chance level we can not say whether the improvement was accidental, or due to a specific factor of whose existence we were unaware.

It seemed quite clear now that in spite of attempted refinements in apparatus and technique which we had hoped would demonstrate the existence of thermal form perception, we were driven back to the conclusions of Experiment 1: thermal patterns (or directions) are reported; their accuracy is extremely poor. The nine experiments following Experiment 1 enable us to say with considerable accuracy *how* poor the perceptions really are: where a measure of chance is available the reports closely approximate it. We can also say, now, that *eliminating the factor of pressure* and *simplifying the task*, as in the present experiment, fail to improve the results under the conditions and with the apparatus that we have employed.

[1] In an informal series of trials in October, 1936, Professor Wertheimer acted as *O*. We used the apparatus supplying radiant heat; the stimulator patterns were C, L and T. Professor Wertheimer was under the impression that they were C, R (rectangle) and T. After experiencing considerable difficulty in obtaining an impression of shape, and pointing out that there were "no boundaries," he decided to "try the experiment of *assuming* that it was a triangle, square and disk, successively: I was able to achieve each of them. They were always filled [not outline] figures." The results were not always so poor: in another trial *O* said, "This is an indefinite impression—it's not a line or a triangle, but it might be a circle or a rectangle, either of these would 'fit'."

III. Experiment 11

Logical considerations had impelled us to abandon stimuli where pressure might be a disturbing factor and it still seemed logical that we should expect better results from the use of radiant heat. Before abandoning the apparatus we felt that we must deal with the possibility that the task required in the preceding two experiments did not make full use of the potentialities of the apparatus. In Experiment 4, in which verbal reports had been reduced to 'Same' and 'Different', *i.e.*, where *matching* (paired comparison) was the procedure, there had been a greater suggestion of accuracy than with other techniques. The apparent improvement could not be fully evaluated because the experiment was abandoned before sufficient data were obtained; and there was also the remarkable fact that *O* correctly reported the shape of each *standard* stimulator. We decided to perform a similar experiment using the radiant patterns.

A. *Apparatus.*

The general nature of the apparatus was the same as in the preceding experiments. The stimulators used were L, T and C.

B. *Experimental Region.*

The experimental region was again the forearm and the back of the hand.

C. *Procedure.*

The stimulators were presented successively in pairs, and *O* reported 'Same' or 'Different' after each pair. In the first few sessions 6 pairs, and after that 9 pairs were presented. L was always the *standard*, and L, C and T the *variables*. *O* had no knowledge of the stimulating apparatus or of the patterns used.

D. *Instructions.*

O was instructed:

"A few moments after the 'Ready, Now' signal you will feel warmth on your arm. I am particularly interested in having you note its shape. Report when you feel warmth and when you feel heat. Soon after the stimulus is removed your arm will be stimulated again and you are to report warmth and heat as before. You are then to tell me whether the second stimulus was *same* (as) or *different* from the first. In each case you may then tell me, as well as you can, the criteria[1] for 'sameness' or 'difference'."

[1] This instruction to report on the criteria resulted, of course, in brief descriptions of the shapes used. This may have violated the principle of simplifying *O*'s task, which was our express purpose. There is no way of saying whether the results would have been better had we avoided this complication of the *Aufgabe*.

E. *Observers.*

A single *O* served in this experiment. He was *Re,* a student in Columbia Law School, who had studied Psychology for one year, several years before. He was—as were all our subjects—completely unaware of the nature and appearance of the apparatus.

The experiment was conducted during October and November, 1936.

F. *Results.*

In each trial the standard might be followed by itself or by one of the other two figures. Thus, on a basis of chance, a report of 'Same' is one-half as likely to be *correct* as a report of 'Different.' Conversely, the report of 'Same' is twice as likely to be *wrong* as the report of 'Different.' Also, on a chance basis (since *O* did not know the number of figures used), we would expect the *same number* of reports of 'Same' and 'Different'; and the *same number* of correct reports as incorrect reports. Table XX reveals the startling fact that the end result of 168 stimulations was a *perfect chance distribution* of the responses, fulfilling each of the predictions that could be made on the basis of chance.

TABLE XX

Showing, for *Re*, the Distribution of Correct and Incorrect Reports of 'Same' and 'Different'

	Number of Stimulus—	'Same'		'Different'	
Session	Pairs	Correct	Incorrect	Correct	Incorrect
I	6	0	1	3	2
II	6	1	2	2	1
III	9	3	3	3	0
IV	9	1	4	2	2
V	9	2	2	4	1
VI	9	2	3	3	1
VII	9	2	4	2	1
VIII	9	2	4	2	1
IX	9	1	3	3	2
X	9	0	2	4	3
Totals	84	14	28	28	14
Totals 'Same' and 'Different'		42		42	
Total correct		42			
Total incorrect		42			

Here, if anywhere, is completely negative evidence on the question of thermal form perception. Our previous statements as to the possi-

bility of *reporting* forms on the basis of meager sensory data, under the influence of a strong set, are fully confirmed by the fact that despite the perfect coincidence of the data with predictions from the chance basis, in almost every case each form was *described*, and an apparently confident judgment as to 'Sameness' or 'Difference' was offered.

A tabulation of O's descriptions resembles closely (and adds nothing to) the results of the earlier experiments, and is equally low in accuracy. It is not included here.

None of the eleven experiments reported up to now is by itself really conclusive, but taking them together, with the successive attempts to refine the apparatus, simplify the procedure and make the O's task easier, we have an unbroken series of negative results. If positive evidence had been obtained at any point, the procedure, of course, would have been entirely different and controls would have been instituted to eliminate possible factors yielding spurious results. But even the admission of such factors (such as knowledge of results and of the length of the series) produced hardly a hint to show that the thermal senses were capable of perceiving patterns accurately. The experiments in which the instructions were so worded that a set towards form was eliminated show that forms are occasionally reported spontaneously but with rather low certainty and the same overwhelming inaccuracy.

In spite of the weight of these successive experiments, it was necessary to be extremely cautious about accepting the results as final. We are safe in stating that *under the conditions employed there is no accurate form perception,* and this, in itself, is a finding which the work in tactual form perception would not have led us to expect. In the next chapter we shall discuss the possible theoretical implications of the findings. At present it is necessary to reexamine our procedures to see whether they have been fully adequate for the demonstration of form perception.

It would be most desirable to vary the *size* of the stimuli. No one knows what the two-point limen is for pure warmth (pressure, *etc.*, excluded) on any portion of the skin surface. If we have been using figures whose dimensions are below the two-point threshold,[1] we can adequately account for our results. We should have an exact analogy to the work of Major [32] where he used subliminal stimuli.

[1] There has been no study of the two-point limen for pure warmth. Dimmick [13] has shown localization to be very poor.

Determining the two-point limen we regarded as a distinct and separate experiment which would lead too far afield at the present time. It was recognized, however, that to be safe in discussing the results we must carry out an experiment using *far larger stimuli*.

IV. Experiment 12.

This experiment was devised for the purpose of establishing whether much larger stimuli than any we had used before—and, therefore, in all probability, over the two-point limen—would produce new results. (See the discussion at the close of the preceding section.) If they did we should be obliged to follow the new lead and assume that our earlier approach had been inadequate. If, on the other hand, the results were not different in kind, we might be justified in bringing to a close this series of experiments (which are, as pointed out before, preliminary and exploratory in nature).

A. *Apparatus.*

With new apparatus we wished to produce an area of stimulation *large enough* to give reasonable assurance that we were not dealing with subliminal stimuli; and to *simplify* even further, if possible, the task facing the *O*. We determined to use a technique in which *discrete 'points'* of warmth would be presented—we produced, actually, not points, but circumscribed *regions* of warmth. The important fact was that these were discrete, permitting, we hoped, differentiation and spatial organization as in Wertheimer's dot-figures [48]. Since this experiment even more than the others, was tentative in nature, the apparatus was crude and inexpensive. The warmth stimulation was produced by three electric soldering irons above *O*'s chest and abdomen. Each soldering iron was ½ in. in diameter at the copper head, which was 3¼ in. long, tapering in its last ½ in. to a 1/16 in. 'point.' Sheet aluminum shields were bent around each soldering iron in such a way that the warmth was concentrated; there was no radiation at the sides that was perceptible when the hand was held a few millimeters away. The diameter of the tubular shield was ¾ inch. The area of the warmth on the skin was determined by the amount of radiation outward from the bottom. At the distance of about 1 in. from the skin which was employed, stimulation of one minute produced an erythromatous region about 1 inch in diameter, which indicated that, physically, the effect of the warmth was fairly well concentrated. *O* lay on a comfortable cot on each side of which were iron supports; his head was behind a black cloth curtain which shielded the apparatus from his view without the discomfort of blindfolding. The stimulators were attached by right-angle clamps to horizontal bars which were, in turn, clamped to the vertical supports. Adjusting the clamps permitted us to raise and lower the stimulators and to move them from side to side. Moving the iron supports bodily permitted movement of the stimulators in the head-feet dimension.[1]

[1] Mr. Norman B. Lefler kindly volunteered to act as assistant in this experiment, where it was necessary for two persons to adjust the apparatus.

B. *Experimental Region.*

O was stripped to the waist and the stimuli were applied at various times to his arms, chest and upper abdomen.

C. *Procedure.*

O, after removing his upper garments, lay on the cot, face-up, with his head behind the black screen. The apparatus, which had been behind a folding screen, was then adjusted so that the stimulators were placed over the desired areas. The stimulators were used two or three at a time; occasionlly only one was used. The purpose was to establish simultaneous but discrete warm regions and to see, first, whether they were discriminated and, second, whether and how they were organized.

To avoid seriously injuring *O*'s skin, the stimulators were placed in position and securely clamped before the current was turned on. *O* reported when he felt warmth and after a period of from 15 to 60 seconds (finally fixed at 45 seconds) the apparatus was again placed behind the screen and *O* gave his report.

Only three sessions were held. The apparatus was rather cumbersome and four trials was the maximum that could be carried out in a period of somewhat over an hour. This small total of trials, however, was sufficient to indicate the trend of the results; and it was the trend rather than quantitative data which concerned us.

D. *Instructions.*

Profiting from our earlier experiences we kept *O* in complete ignorance of the nature of the apparatus and the purpose of the experiment. The instructions were as follows:

"You are to lie down on this cot and make no attempt to see beyond or around this screen. You are to lie *quietly*—do not make any movements without first warning the experimenter. After the apparatus is adjusted, the experimenter will say 'Now.' Some time afterward you will feel warmth—you are then to report 'warm.' — seconds later the stimulus will be removed and you will be called upon to *describe the experience* as fully as possible."

O doubtless knew that the stimulus would be applied somewhere between the neck and the waist, since he had uncovered that region, but the experimenter was careful not to indicate in any other way the locus of stimulation.

E. *Observers.*

Sch, an undergraduate in Columbia College taking the first course in Psychology, acted as *O*. He knew merely that he was taking part

in an 'experiment' and received only the information that was in the instructions.

This experiment was carried out in April, 1937.

F. Results.

The small number of trials and the importance of the qualitative rather than the quantitative findings make it desirable to describe each trial separately.

1. *Series One.*

Trial 1: Three stimulators were placed one about 2 in. cephalad of the navel and the other two, symmetrically, about 2 in. below the collarbone, and about 4 in. from the sternum, on either side. The stimulus was removed 15 sec. after *O* reported 'warm.'

(In all the following descriptions the 'landmarks' are supplied by the experimenter: *O* simply pointed to various regions and *E* noted these down in rough anatomical terms.) *O* reported the experience as follows: "There was slight warmth—like a *sheet* of warmth from the end of the sternum up towards the shoulders—but not on the outside of the shoulders. It was more intense around both shoulders, particularly the left." Asked to describe the experience further, *O* continued: "It was mild warmth, least intense on the lower part. It began in the lower part [around the end of the sternum] and worked itself up. I sort of had the feeling as though a *warm cloth* were laid down [no pressure was felt]—as though you laid it down beginning at the lower end. It seemed all on the top of me—on the upper surface of my body."

This is a remarkable report. Although the three stimuli were widely separated and rather limited in physical radiation, we hear of "a sheet of warmth," covering the whole "upper surface." The boundaries are determined by bodily contours: "it seemed all on the top of me."

In the second trial one stimulator was placed over each nipple, and one about 1 in. cephalad of the navel. The stimulus was applied for 15 sec. after *O*'s report 'warm.'

Sch's report: "This time it seemed to start lower down—just above my belt. [This was correct.] It seemed to spread out more towards the sides [pointed on each side to the lower margin of the ribs], and didn't go up as far. It stopped an inch or more above the nipples [indicates line running from one side of the chest to the other]. The whole region with those general boundaries—and pretty much *on top* of the body—was warm. It was very mild, less intense than before."

Again the upper and lower boundaries correspond roughly to the position of the stimuli, but there is *no discrimination* of the separate stimulators; there is rather a gross generalization, the boundaries being determined more by bodily contours than by the objective margins of the warmth.

In the third trial the two upper stimuli were applied just above the biceps on each arm and the third about 1 in. below the navel. The 'warm' period of stimulation was 30 sec. *O*'s report was unusually interesting:

"This was perhaps a little more intense although still mild. [Apologetically:] It was as though I were lying under a tree with shade on the upper part of my body. I felt it 'hit the way' the sun does, right down here [across the region just above the navel, and from one side to the other]. Then it seemed to spread up both arms. It seemed to go up the arms higher than on my body. It didn't go below my elbow or above the top of the [biceps] muscle." The complete description was of a 'strip' or 'streak' of warmth forming a sort of arc across the body just above the navel (approximately 4 in. broad), and taking in a similar region across the lower part of each upper-arm.

We have again no suggestion of discrimination of the three warmed regions, but rather an extraordinary organization which even extends across different sub-Gestalten of the body (such as the arms). One may also note the fact that the experience is localized below the actual position of the upper stimuli and above that of the lower one.

In the final trial of the first series, two stimuli were placed about 1 in. cephalad of each nipple, and about 4 in. apart, equidistant from the midline. The third was placed over the lower end of the sternum. The effective duration of the stimulus was 60 sec.

Sch's description of his experience was in these terms: "It started out over here [a small region midway between the midline and the left side, at the lower margin of the ribs]. Then it worked over to the middle and up so that there was a warm line [from just below the sternum extending upward for about 1 in.]. From there it spread outward on both sides [a region above the end of the line, about 6 in. wide, extending upward 6 or 7 in.]. The first region [below and on the left] remained, but decreased in intensity as the line became more intense. Then the second change [spreading at the top] came quite suddenly, with the intense line remaining. . . . The different warm regions were connected, but it was like two regions of intensity—the boundaries overlapped as two ink-blots might."

Although we can not account for the localization of the first region of warmth described, the rest of the description seems to fit the stimulus conditions fairly well. It is interesting that the description of the line—such a sharply defined area was very rare—followed the lines of the slight depression that lies over the sternum. This is further evidence of the influence of the contours of the body in determining the experienced pattern. There was also considerable differentiation within the warm area, but it seems to depend on *temporal* differentiation.

2. *Series Two.*

In the first trial of the second series, two stimulators were used: one over each shoulder-joint. The stimulators were slightly more than 1 in. above the skin. They were removed 40 sec. after *Sch*'s report of 'warm.'

He reported: "It was right over in these parts here [accurately localized]. They were localized, small regions. I felt it first on the right-hand side." In response to a question, *O* affirmed that he had felt two separate regions.

This was our first indication of accurate discrimination. Such discrimination occurred when only two points were used, when they were widely separated and when they were over *moving* and '*distinguished*'[1] parts of the body. We can not judge at present which of these was the determining factor.

In the next trial the two stimuli were placed directly over the nipples at a distance of about 1½ in. The stimuli remained in place 30 sec. after the report of 'warm.' *Sch* said: "It started over here [placing the flat of his hand on the far right side of his chest, below and to the right of the nipple] and spread up under my armpit, becoming more intense; then it came in towards the middle of my chest forming sort of a blunt point—[*E*: "a triangle?"]—a trapezoid [parallel sides being the outer margin and the margin in the middle—the sternum. The nipple was within the figure.]."

There were several unusual features in this report. The 'distinctiveness' of the nipple did not play the part expected in the organization of the warmth. Second, the stimulation to *O*'s left, although actually slightly closer to the body than that on the right, apparently played no part in the total experience. Finally, for the firts time, a description was offered (in response to a question) in terms of geometric form.

In the third trial two stimuli were placed 1 in. from the skin surface, about 9 in. apart, on a line extending from side to side about 1 in. cephalad of the navel. 45 sec. of 'warm' were permitted before the stimuli were removed.

The result was very similar to that of the preceding trial. Warmth was first reported on the right hand side of the body, in a region extending, roughly, between the point where the stimulator was applied and the right margin of the body, about 1 in. above the stimulator and 2 in. below it. "Then it spread a bit towards the middle of the body. That's about all there was to it."

In the final trial of this series two stimuli were used, one just below the belly of each biceps muscle, about 1 in. from the skin. There were 45 sec. of stimulation.

After the removal of the stimuli, *Sch* reported: "It started out on the right arm just below the elbow and then spread below about to here [about 3 in. above the wrist]. There was warmth on the left arm, also, on a very small area [which was warmer than on the right arm] just a little below my elbow."

Although the stimuli were at least 2 in. *above* the elbow, warmth was reported *below* the joint. This suggests a tendency to localize warm sensations on the arm away from the shoulder joint, although, of course, it is dangerous to speak of a 'tendency' on the basis of two trials.

[1] Schilder [38], in discussing a patient with marked disturbances of localizing ability, says "It is worthy of remark that the patient usually localized correctly a touch on her nipple. There are certainly points which are so distinguished in their individuality and character that they are easily brought in connection with the optic model of the body." (p. 20.)

3. *Series Three.*

In the first trial of the third session, two stimulators were used, each about 1½ in. below the nipple. The 'warm' period was 45 sec. and the distance of the stimulators from the body approximately 1½ in. (in all the trials, of course, this measurement varied somewhat with the breathing movements: here 1½ in. was the approximate *maximum* distance of the stimulator from the skin surface).

The description in this case was as follows: "The warmth started here [pointing to a region fully 4 in. below the locus of the stimulator, on *O's* right side] and worked up the side of my body [the outer margin of the upper part of the right side of the chest] to my armpit, and then it spread over to the middle of my chest [in a 'band' whose lower margin was again at least 4 in. from the stimulator]. It was most intense here [a region directly cephalad of the location of the stimulator but opposite the armpit]. Then another region started [symmetrical to the region just mentioned] on the other side and came over to merge with the first in the upper middle part of my chest—and about that time the lower part of the first faded out."

While inadequacies of the apparatus, radiation of warmth and conduction of warmth by the skin, etc., might be partly responsible for the wide extent of the warm regions here reported, it is somewhat difficult to account for the fact that warmth was never described at the portions of the skin directly underneath the stimulators, at which point narrowly defined and definite redness could clearly be seen. The contours of the body seem influential once more in determining the 'pattern.'

In the second trial of the third series but a *single* stimulator was employed. This was placed about ½ in. below the end of the sternum, and a little over 1 in. from the skin surface. The effective stimulus duration was 45 sec.

Sch's report: "The warmth started here [an area about the size of the palm, far to the left side of the body, over the lower ribs] and then spread this way [along the inner margin of the ribs, upward and toward the sternum], losing intensity at the original spot.'

At no time was the warmth experienced *at* the region stimulated nor is the fact that the 'bias' was to the left easily understandable. Although the stimulus was on the abdomen *between* the inner margins of the ribs on either side, the warmth reported followed the contour of the ribs of the left side.

In the third and final trial that time permitted, the three stimulators were used again. One was placed over the midline of the body about 1 in. away from the skin and about ½ in. below the line formed by the nipples. The other two stimulators were placed, symmetrically, over the margin of the ribs on a line with the nipple and a little more than 2 in. cephalad of the navel. There were 45 sec. of stimulation.

Sch described a region of warmth which 'filled' the region enclosed by the rib margins, with the lower boundary approximating a line formed by the two symmetrically placed stimulators. There were several 'outshoots' of warmth on each side, which apparently followed the line of several ribs on either side of the lower end of the sternum.

We have interlarded the reports in this experiment with discussion and comment; we may reiterate merely that there is a great deal of

evidence to show that anatomical contours can influence the experiences. We cannot say with finality whether the contours act to 'direct' the physical stimulation or, as we consider to be more likely, *provide the terms* in which the pattern is experienced psychologically.

G. Discussion.

The results of this final experiment are not different in kind from the earlier findings, although the stimulus pattern was so large; in all probability, beyond the limits of the two-point threshold. We feel justified in making a tentative assumption, then, that the preceding eleven experiments are *not irrelevant* in the sense that Major's in the tactual modalities would have been if he had reported *only* those trials in which he used stimuli below the limen for form. If even the gross forms employed in the present experiment are inadequate, we can say, at least, that we have closed a chapter in this general field of Perception of Thermal Patterns, and conclude that further work should be directed toward such problems as the two-point threshold for pure warmth, or the discrimination of very gross areas of warmth, such as where an entire half of the body could be warmed or cooled. We are, in other words, reasonably safe in assuming that perception of patterns of the type that has long been known in vision and that has been demonstrated in a dozen experiments in the tactual modalities is not present here.

The trials of the twelfth experiment add to what we had previously learned, besides the negative point just made, certain positive suggestions. These we shall discuss in the next pages.

Katz [27] has discussed the 'bi-polarity' of the cutaneous senses. "With respect to objectification and subjectification, the phenomena of touch and the phenomena of colour must be placed in different positions. Colour-phenomena are always characterized by objectification; they are always seen 'out there' in space." (pp. 36-37). "With touch phenomena, however, it is quite different. Here we have a combination seemingly indissoluble, of two components, one subjective with a body reference, and the other objective, suggesting properties of objects. For this reason I have described touch phenomena as bi-polar. At one moment the subjective pole in a touch phenomenon may be dominant, and at another moment the objective pole, but this bi-polarity always persists. The same holds true for impressions of temperature. The very expressions we use when we talk about sensations sometimes reveal the distribution of accent. 'When we formulate judgments about temperature we say sometimes as we could in dealing with vision: "It is warm, it is cold" and sometimes, as we could never do in connection with vision: "I am or I feel warm or cold." ' "[1]

This reference of the cutaneous experiences to the *self* rather than to an object is clearly confirmed by *Sch*'s reports. Warmth is never

[1] Katz quotes from Ebbecke [16].

referred to as something 'out there.' This was even clearer when his reports could be heard. The necessity of inserting anatomical descriptions, more or less precise references to parts of the body and careful 'measurements' give a tone of objectivity which was not there. If we *are* dealing with a modality where, as Katz says, experience is usually subjective, perhaps we have no basis whatever to expect that patterning should be at all like the type we find in vision; rather, we might say, there should be a patterning which is largely dependent on the contours of the body: that is, a *subjective kind of patterning*. This is in harmony with the results of Experiment 12.

At this point we may quote remarks made by *O* after the last trial, in response to some questions.

Sch was asked whether he could make any statement as to the nature of the stimulating *object*. He was rather surprised, pointing out that he had been concerned with "the warmth". When pressed, he described a cross piece with two standards, the center of the apparatus being capable of adjustment. This was correct, but was derived from the auditory and visual cues rather than cutaneous ones. He recalled that there had, at times, been an intense central spot of heat with warmth spreading from there, and believed that the apparatus was of a nature which permitted concentration and later diffusion or spreading of the warmth. He was asked whether there were more than one such spot and replied that he did not know. *O* was told that in the last trial there had been three sources of warmth and thereupon expressed considerable surprise; he then corrected himself (his surprise) and said that he did recall three foci which he located more or less correctly. This running excerpt from *O*'s general comments points rather emphatically to the subjectivity of the experience.

In Chapter One we mentioned a dozen experiments indicating that forms could be more or less accurately reported in the tactual sense. In terms of the polarity principle this is understandable: vision, a highly objective sense dealing with the outside world invariably, is a 'good' instrument of form perception, touch which is bi-polar (that is, either objective or subjective) is poorer than vision but far superior to the apparently similar temperature sense which is, according to Katz [26], *primarily* subjective and correlatively incapable of accurate perception of objective patterns.

It is obvious that this discussion is now leading us far beyond our original problem: it is becoming clear that we can no longer hope to deal with form perception in the thermal senses as a distinct problem. Setting aside the possibility that our negative results may be overthrown by the use of different techniques, and assuming their validity for the purpose of discussion, we see that we have come to a point where the nature of *perception in general* in the temperature senses must be taken into account. Such a consideration we shall reserve for the next chapter.

CHAPTER FIVE—INTERPRETATION AND THEORETICAL IMPLICATIONS OF THE FINDINGS.

I. Some Qualifying Remarks.

The 'chronological survey' of our experiments has been concluded. We may consider the twelve experiments now as a whole. In doing so, we may be permitted to point first to several of their weaknesses and to assume that these will be taken as qualifying statements for what follows.

First, in all the experiments taken together, only 16 different individuals have served as *O*s and in certain of the experiments but a single *O* has been employed. This was unavoidable in the present type of study where rather intensive work is done with each individual; and the defect is far from fatal in seeking the general nature of phenomena rather than fine statistical measures. Moreover, our main conclusions were derived from the unequivocal results from *all* of the *O*s and were concerned with individual variations only in so far as the *fact*, itself, of individual variation is of importance to us. There is no attempt to secure highly reliable or detailed measures of the direction or extent of such differences.

A second weakness to be mentioned is that of apparatus, since on one occasion after another we have spoken of apparent flaws. Here, however, the case is different: we need not even deplore. In each case the apparatus used fulfilled definite criteria set up in advance: criteria laid down because of the requirements and difficulties which could be *foreseen*. Apparent failures of the apparatus, then, are due to difficulties which were not always foreseen and which may be taken therefore as indications of failures of specific hypotheses regarding the nature of form perception in the thermal senses. This is not true, however, of one of our apparatus problems. We refer to the inability to adapt the radiant stimuli to the curvatures of the body in such a way that their projections on the body—and not their objective shape—represented true geometric forms. The latter was the desideratum; it was achieved in an unknown number of cases.[1]

[1] This difficulty in fitting the form to the body-contour was shown in an experiment we had to abandon after brief trials, after having constructed a fairly elaborate apparatus. *O* stood before a screen of Cellotex which was

An analysis (not given here) of the trials in Experiment 10 failed to demonstrate that removing this source of trouble would improve the accuracy of *O*'s reports. In each trial a hasty sketch was made indicating the relation between the stimulator and the contours of the arm. These were classified as 'Perfect' (the stimulator—L—apparently perfectly parallel to the arm at a distance of about 1/32 in.), 'Good' (part of the stimulator as much as ⅛ in. further away from the skin than the part that was closest), and 'Poor' (where part of the line was as much as ¼ in. further from the skin than the closest part; however, if over one-third of the line was at this distance we re-set the apparatus. Finally, even though it be *ad nauseam*, we wish to emphasize our own realization of the insecure foundations negative results provide for drawing conclusions.

II. Summary of the Experiments.

Let us summarize briefly the salient findings in each of our experiments before going on to consider their interpretation.

Experiment 1. Cooled copper patterns (disk, rectangle and triangle) were used in contact with the skin; pressure was controlled by a uniform surround of hard rubber for each pattern. Using the chests and abdomens of three *O*s as the experimental field, we determined that *patterns were reported* in an overwhelming majority of cases but that the reported *patterns were overwhelmingly inaccurate*. We also found that each *O* differed sharply from the others in the specific shapes reported, although the stimuli and conditions were the same.

---

covered in front and in back with aluminum foil, the whole being a very satisfactory heat insulator. Through the foil and the screen was a slit ¼ in. wide and 8 in. long. The apparatus was so adjustable that the slit could be made to rest parallel or at right angles to the long axis of *O*'s body. Directly behind the slit was a heater constructed of an 8 in. coil of Nichrome wire and mounted in an iron support, with an aluminum reflector concentrating the heat on the slit in the screen. It was hoped that this large counterpart of the experiment in which the *O* was to report whether a line ran 'Across' or 'Along' his arm would serve the function of a final gross experiment, designed to show whether our previous apparatus had been so inadequate in size that positive results could not be expected. It was found in the course of a few preliminary trials that the contours of the chest or the back presented so many hills and valleys that the projection of the stimulus was largely destroyed. A trial in which waxed kymograph paper was placed over the surface of the body, so that the melting areas of the wax would show the distribution of warmth on the skin, indicated a definite difference between the 'horizontal' and 'vertical' positions of the screen, but we decided, nevertheless, since the differences were not as clear-cut as we wished, to turn to the apparatus actually employed in Experiment 12. The *O*s in the preliminary trials found it utterly impossible to distinguish between the two stimulus positions. One of the *O*s was Professor A. T. Poffenberger.

Experiment 2. Using apparatus which differed from that of the first experiment in the increased size of the hard-rubber disk (in an attempt to reduce interference from pressure), this experiment with five *O*s established for the *warm*-sense the same facts that were determined to hold for the cold-sense in Experiment 1. The difference between the *O*s were less marked.

Experiment 3. In order to find the exact relation of correct reports to chance and at the same time to lighten *O*'s task, we permitted knowledge of the stimulators and knowledge of results. The brief experiment, using one *O* and the same apparatus as in Experiment 2, suggested no superiority over chance.

Experiment 4. In view of the possibility that *description* of thermal patterns might be inaccurate, while simple *discrimination* might be possible, a matching (paired comparison) technique was used with one *O* and the apparatus of the previous experiment. Although merely a report of 'Same' or 'Different' was required, the short series of trials completed showed *chance results* (and a slight improvement from the first to the last series, indicating the possibility that learning was taking place).

Experiment 5. Using *radiant patterns* which gave circular, square and triangular outlines (in order to eliminate contact), on two *O*s' arms, this experiment was designed to parallel Experiments 1 and 2. There was no indication of the superiority of the present technique (radiant stimuli) over the earlier one used.

Experiment 6. This experiment was intended to parallel Experiment 3, using the apparatus of Experiment 5. With a single *O*, knowledge of results failed to bring out any accurate form perception.

Experiment 7. The failure of the preceding experiments to demonstrate true perception of form made it necessary to determine the *effect of the instructions,* since shapes were reported. Using the apparatus of the preceding experiment, with two *O*s, the instructions called for 'description', making no mention of forms ('free report'). The results indicate only *a slight tendency to report shapes spontaneously.* The actual number of such reports, while not negligible, is strikingly smaller than in the previous experiments.

Experiment 8. Since, in Experiment 5, the instructions had been less specific than in Experiments 1 and 2 in requiring reports of shape, Experiment 8, using one *O*, emphasized this requirement in order to provide a comparison with Experiment 7. The apparatus was the same. The results of Experiments 7 and 8 show extreme contrasts, the incidence of reports of pattern being 100% here, and as low as 7% in Experiment 7, indicating the potency of the instructional set.

Experiment 9. Using, instead of the geometric forms of the preceding experiments, a simple line, two *O*s were required to determine whether it was *parallel* with or at *right angles* to the axis of the arm. The apparatus was again on the radiant principle. Again only *chance results* were obtained.

Experiment 10. Here, using the same *O*s and conditions as in Experiment 9, knowledge of results and rewards for accuracy above chance were introduced, but *no learning* was evident and the results remained at a chance level.

Experiment 11. Using the apparatus of the later experiments and the matching technique (See Experiment 4), a single *O*'s reports over a series of trials were found to correspond precisely to those that could be predicted on a *chance basis.*

Experiment 12. To determine roughly whether the previous results were negative because of a gross inadequacy in the size of the stimulators, Experiment 12 employed one to three radiant sources arranged in varying patterns over the upper abdomen, chest and arms of a single O. The instructions did not require reports of shape. The reports suggested no perception of geometric patterns as occurs in visual 'dot-figures' nor were the 'points' usually discriminated. The report of continuous regions of warmth suggests a patterning or organization of some sort, with the bodily contours apparently exerting a strong influence.

Each of these experiments, taken alone, is subject to a variety of criticisms. Taken together they constitute a powerful body of evidence univocally denying the perception of form in the thermal senses. Under the various conditions we have employed, there is no evidence of accurate perception of simple geometric forms in the cold- or warm-sense. The tendency to report consistently certain inaccurate forms, which earlier puzzled us, is accounted for in *most* cases by the simple fact that the *instructions called for them,* and in the labile type of situation apparently involved, there was no difficulty in adopting the suggestion implied that forms *should* be perceived. Such reports are largely dependent (although the determining factors are not really known) on individual preferences and predilections. Even in a simple situation with a powerful incentive, there was no demonstrable improvement.

III. Technical Factors that Might Account for the Findings.

Our basic problem, of course, was to determine whether the senses for warm or cold, 'on their own,' were capable of the discrimination of simple geometric patterns. While it has not been possible in the present study to investigate all the possibilities, there are certain conditions under which it is conceivable that such perception *might* be demonstrated.

A. *'Stimulus' and 'Object.'*

One of these possibilities bears on the relationship between the stimulus and the pattern of cold spots or warm spots which it arouses. That is to say, it might be argued that in view of the sparseness of the temperature-spots in comparison to the pressure-spots, we have at no time had the possibility, such as exists in the touch sense, of stimulating a *pattern of 'spots'* which was triangular or circular, for example. This problem has been discussed in some detail in Chapter Two, Section I, F, 4, a.

B. Neurological Considerations.

Another possible explanation of our findings would rest on a neurological hypothesis. Since the nervous subtrate for temperature has never been satisfactorily demonstrated distad of the trunks of the sensory nerves [12, 3, 9, 21, 24], we do not know whether the fibres leading from the end organs form plexuses before joining the nerve trunk. If such a structure is the rule, then we must think of a diffuseness characteristic of the uninsulated autonomic nervous system, rather than the precision and differentiation of the central nervous system. We would not expect that a *figure* could be differentiated, where the neural foundation of such differentiation would be lacking. Indeed, in the series of studies referred to above there is some evidence [3, 9] suggesting that the temperature excitations *are* carried by autonomic fibres. The author does not feel that Nafe's theory [34] is supported by any but presumptive evidence and he is of the opinion that contrary evidence is at hand; without entering into the merits of the view, however, it is seen that its adoption would tend (as does the above-mentioned possibility of a plexus of fibres) to make improbable, on a physiological basis, the possibility of form perception. In Nafe's theory, temperature experiences are produced by the stimulation of end-organs in the muscle walls of the surface blood vessels, which are thrown into activity by the contraction or expansion of the arterioles in response to changes of temperature. On these grounds, one would expect diffuseness of excitation of the thermal system, with the impossibility of boundaries and the improbability of any but very loose spatial organization. Either of the theories just outlined would be harmonious with our data: denying the possibility of real organization, except, perhaps, when widely separated, and therefore neurally discrete areas are involved. Either view would on *a priori* grounds deny the possibility of perception of geometric forms in anything like the manner in which it has been found in touch.

C. Size of Stimuli.

It has been suggested that our stimuli might be too small: that they might be below the size-threshold for temperature. (Here the apparatus question comes up once more—see the beginning of this chapter.) Such a threshold has been demonstrated for pressure: it is analogous to visual acuity. Experiment 12 was designed expressly to meet this question and despite the fact that only a relatively few trials were made, with a single *O*, we feel that the experiment answers

the objection. In the discussion at the end of the last chapter it was pointed out that larger stimuli would involve another type of discrimination than that associated with the perception of geometric forms. On such a basis an individual would require several bodies to perceive a simple shape!

D. *Nature of Stimuli.*

Another objection might be made to our technique in connection with the apparatus. In the first type used (Fig. 1) we had physically clear boundaries, but we dealt with areal rather than outline forms. In the second form of the apparatus (Fig. 4), the conditions were reversed: we were using outline figures, but because of the nature of radiant heat the outlines were 'fuzzy' rather than sharp. It was suggested to us, in fact, that the nature of the radiation might be such that no triangular pattern of radiation was present at all. To test this possibility, each of our radiant forms was suspended 2-3 mm. over the surface of waxed kymograph paper, and the current switched on. After a time considerably longer than any ever used with an *O* (because the melting-point for paraffin is higher than the physiological threshold for warmth), the wax melted, indicating the radiant pattern. In each case the pattern was an outline figure, clearly that of the stimulus (to visual inspection), although with 'bands' rather than 'lines' forming the boundaries. True, the wax provided an 'all-or-none response' while the skin would be sensitive to finer gradations of intensity: nevertheless we feel that we successfully demonstrated the physical reality of the radiant shapes. Unfortunately, the 'wax-patterns' are not suitable for reproduction here.

There is no reason to assume, at present, that our apparatus was inadequate to the production of physically 'real' patterns impinging on the skin.

IV. Some Theoretical Implications

A. *Nativism and Empiricism.*

When this research was first conceived, we thought of it as perhaps having, ultimately, some bearing on the old nativist-empiricist controversy. But for occasional references in textbooks and in such reviews as Carr's recent book [8][1] this problem has been largely relegated to the background, as being incapable of resolution by critical experimentation. The principal reason for assuming such an

[1] [8, p. 403] "The usual discussions of the native or empirical nature of space are wholly futile."

insuperable difficulty was that by the time it is possible to obtain verbal reports from children, or even to experiment adequately otherwise, there has been the possibility of a great deal of 'training'. Our argument was that in the temperature senses we are dealing with modes of experience which have never been *trained* in form perception, and (without taking into account, at that time, the possibility of completely negative results), if at first application of warm or cold patterns we obtained descriptions of *forms,* we should have presumptive evidence favoring the nativistic view. If, on the other hand, such perception could be established only after a course of training, the evidence would favor the empiricist position. The fact that even with intensive efforts to encourage learning no such perception could be demonstrated, may seem to make our results useless for the purpose of entering this discussion. In the next pages, however, we wish to develop very tentatively a theoretical point of view which (borrowing heavily from the opinions of others) may lead to possible integration of the crude empiristic or nativistic approaches and which is capable of empirical verification, if technical difficulties can be overcome.

In many respects *Gestalttheorie* is the modern nativistic doctrine. We might consider, for instance, Kurt Koffka's discussion of "Why Things Look as They Do" [29, Ch. 3]. His answer is that "Things look as they do because of the field of organization to which the proximal stimulus distribution gives rise. This answer is final, and can be so only because it contains the whole problem of organization itself * * * It means that we have to study the laws of organization." [29, p. 98]. In studying the principles of organization Koffka distinguishes between external and internal conditions, "the first being those created on the sense surfaces by the proximal stimuli; the second being inherent in the nervous structure itself". The nervous structure supplies both permanent and temporary forces: only the former concern us now. These are "of the constraining and insulating sort; they will favor certain interdependencies rather than others * * *" There is an emphasis on internal forces which are, says Koffka, characteristics "in the nervous system as a whole." This is in opposition to the crude empiricist who denies *any* native determiners of perception except in so far as we have end-organs differentially sensitive to various kinds of energy.[1]

[1] We should say at this point that a real 'empiricist' is as rare today as the 'atomist' the Gestalt psychologist has attacked so violently. Consider, for instance, the following quotation from Carr [8]:

"The visual field exhibits a spatial pattern. It is a sensibly continuous

B. *An Attempt to Verify Some Deductions Made From Koffka's Description of 'Internal Forces'.*

While Koffka in his beautifully logical elaboration of the functions and properties of internal and external forces is concerned with visual perception, we are justified, it seems, in trying to apply what he says to our investigation, on the basis of his characterization of internal forces as "in the nervous structure". We shall return shortly to the main question.

The external forces are those of the 'proximal stimulus', which is to say, the actual pattern of energy impinging upon the sensory field, as distinct from the object which is its source (the distant stimulus). An example of such an energy pattern is the external image. Discontinuities in the proximal stimulation are necessary for the segregation and formation of a unit.

The internal forces are those that exist within the "process in distribution itself and which will tend to impress on this distribution the simplest possible shape." [29, p. 138]. They are characteristics of the entire nervous system. When the situation is one in which the *external forces are weak*, perception is largely determined by the internal forces. As concrete examples Koffka cites studies in perception of visual shapes where there was very brief exposure, low intensity, small size or where after-images were used. "The result has been the same throughout: simple, well-balanced figures are perceived when irregular figures are actually exposed." A precise parallel to these visual experiments is, perhaps, present in our own conditions. The irregular distribution of the warm spots, the small sized figures, *etc.*, may well have produced 'irregular figures.' The *Os'* reports, particularly their initial ones, suggest a situation in which the proximal stimulus was vague, not very well bounded and somewhat unstable; that is, exactly the kind of situation in which the external forces are weak and the operation of the internal forces should be clearly demonstrable. That a 'unit' was 'segregated' is shown by the fact that *all Os* spoke of isolated warm regions. But

---

magnitude which exhibits differentiations in respect to position within the whole. All visual objects necessarily exhibit the attributes of size and shape in virtue of the fact that they are differentiations within the extended whole." (p. 359). "* * * we can give an unqualified approval * * * [to the view] * * * that extension and continuity are given congenital characteristics of the visual field so far as individual development is concerned * * * [and] * * * the admission that local signs in the sense of local quales have no observable existence." [p. 360]. For a similar statement see Boring [4, p. 99].

what should the internal forces have 'done' to this unit under these conditions? It is possible to list some specific predictions applying to this case:

In general, "simple, well-balanced figures" should be reported; we should expect *simplification* of form.

Specifically, such forms should be a—: "more symmetrical", b—should have "rounded instead of pointed corners", and c—we should expect to find "gaps closed". "With weak external organizing forces the internal ones are strong enough to produce considerable dislocation *which lead to more stable shapes.*" (my italics). The forces operate even to "produce new material processes if thereby the figures become more stable * * *".

In our experiments, we can test Gestalt principles to some extent, under conditions where no training has been possible. This was by no means the case in the experiments cited by Koffka in support of his views, since they all deal with *vision*. We can see, at least, whether the specific statements made by Koffka are upheld in a situation apparently analogous to that he describes; we have merely to examine those trials in all our experiments in which each *O* reported forms and then see to what extent those forms comply with the predictions made.

We should expect, if not perfectly round figures, at least a *predominance of curvilinear* over rectilinear ones. An ellipse should be reported more frequently than a rectangle, a circle than a square, irregular figures should be curved rather than angular. Tables IV a-c and VI a-e give some data on this question. We find a predominance of curvilinear forms. It is by no means overwhelming. Moreover, several *O*s show quite the opposite trend. *Po,* for instance, in the first experiment, showed a marked preference for such highly '*un*curvlinear' shapes as triangles and wedges. *Ka*'s descriptions were of lines and unusual combinations of lines, frequently angular rather than curved: in many cases far from simple in any sense. The same may be said of the reports of *Sch,* in Experiment 12, which were given verbatim. We can hardly consider this a verification of the first hypothesis.

The second possibility to consider is that of *symmetry*. To determine whether each figure reported was symmetrical is an ambitious task we have not attempted. We prefer, rather, to point to the tendencies shown by each *O*. In general we see a very definite tendency to report symmetrical, balanced figures, although, again several *O*s are exceptions, and strong exceptions. *Ka, e.g.*, reported numerous, highly individual shapes which had no semblance of sym-

metry or balance. It may be mentioned that the crude criterion of symmetry that we have kept in mind in classifying each *O* has been that of *bilateral* symmetry.

We are told further that in a situation where internal forces are the primary determiners of the final form *gaps should be closed.* We have the more reason to expect that there should be *no incomplete forms* reported since all of our stimuli were closed patterns. Nevertheless, incomplete forms have been reported. In *Po*'s reports, for instance, we find a very large proportion of such forms: the same is true of other *O*s in lesser degree. The actual proportion of such reports is not very great but their presence is certainly contrary to the hypothesis.

Symmetry, rounding and closure are all characteristics of 'simple' or 'good' form. Again, however, there were a number of descriptions of complicated, not to say bizarre, shapes. An enumeration of these is unnecessary. *Ka*'s reports may be cited in this connection. Since our stimulus forms were simple and since the internal forces should operate in the direction of further simplification, we are left again without a satisfactory explanation, unless we revert to the facetious suggestion made earlier that the principle of the Rorschach test was operating here. No *O*, in any experiment, showed a tendency to perceive *circles* exclusively, the result which would best fulfill all the characteristics of 'good form' attributed to the operation of the internal forces under weak influence of the proximal stimulus.

The results here viewed, then, are very different from those in the visual experiments on after images, small figures and similar situations, which Koffka cites as crucial evidence for his description of the operation of the forces of the nervous system.[1] It is sufficient here for us merely to state this fact. The reason may be inadequacy of the theory or an error in applying it. We do not feel that a crucial point has been reached, since we have partial proof and partial denial of the separate hypotheses. Certainly the opening of this new field for investigation of perception did make it possible to consider such theories more critically. It is easy to over-generalize the re-

[1] This is not to be considered as a 'refutation' of Gestalt principles. We shall show, below, that certain more general principles seem to apply and, of course, some grounds may be discovered to show why we should not assume that our situation fits that of the crucial case set by Koffka. Nor does each statement of Professor Koffka necessarily implicate Gestalt psychology—as a whole!

sults from a single modality and it is useful to know of an apparently untrained modality in which partial verification may be sought.

C. *Thermal Patterns and 'Motor Theory'.*

The preceding section was a digression from our main theoretical problem: Why do we *not* perceive shapes by way of the thermal senses? We discussed Koffka's views because they seemed directly applicable to our experimental situation and because as a 'modern nativism' they imply (to us) that certain organizational characteristics of experience (actually functions of the nervous system), should be demonstrable in our data. As we saw, only partial confirmation was possible.

What can be said, then, to account for the lack of similarity between the visual or the tactual modality and thermal sensitivity, beyond the physical and physiological hypotheses offered earlier in this chapter? If we are to think that our negative results may not be conclusive, the remaining possibility is that the thermal senses are *trainable,* and the techniques we employed in an effort to produce 'learning' of form perception (Experiment 10, for instance) were inadequate to demonstrate this potentiality. It is probable that training of the knowledge-of-results and reward type, such as we used, is not suited to show improvement in thermal form perception. *Activity* of some sort is probably necessary. This statement clearly implies a motor theory of some sort: what kind of theory is meant?—and what justification do we have for using it?[1]

'Motor' theory is a term which has been applied to many kinds of theoretical description. We are concerned here with *the motor theory of the development of form perception and spatial discrimination, applying particularly to the cutaneous senses.* We shall speak interchangeably of thermal and touch experiences: the view we shall develop assumes that the same principles are applicable. We do not propose to consider its relevancy to vision.[2] Basically the theory would state that tactual experiences are originally diffuse, undifferentiated and attributed to the self: simply to the body as a whole and not to a well localized portion of it. Localization would occur only on the basis of kinesthetic experience visually organized. When

[1] The author wishes to thank Professor Murphy for stimulating him to think in this direction. The particular view taken owes much to Professor Goldstein.

[2] For a negative statement of the application of such a view to vision, see Köhler [30, p. 168 ff.]

I locate with one hand the itching point on my chest, and *see* it, and when I have done this a number of times, only then can I localize it; that is, 'know' where the point is. The topography of the surface of the body is established in this way. The individual who is paralyzed from birth would never be able to localize a contact on the surface of the skin unless it were within the visual field. Ahlmann [1] has shown that a totally blind subject, even though not congenitally blind, after a few years of blindness is unable to localize a contact on the body unless he is permitted to make at least an incipient movement of localization.[1] The experience is that of an undifferentiated contact or a displacement of the entire body. But why is this not true of normal individuals when their eyes are closed? Why the importance of vision? The topography of the body has been established visuo-kinesthetically, the complete 'schema' [38] can be carried only in visual terms: deprivation of vision throws the individual back on his motor resources, and he is unable then to localize without incipient movement.[2] The important part of this process, for us, is in the

[1] Crucial evidence on the importance of vision in constructing spatial schema should be obtainable from accounts of the congenitally blind who have been made to see. However, to the author's knowledge, none of the cases reported has been studied satisfactorily from this point of view.

[2] Goldstein distinguishes sharply between 'reflex localization' to an injurious stimulus and the type of localization that is involved in answering the question 'Where did I touch you?'.

Washburn [45, 46] has presented a motor theory of perception in which she rejects the view that her theory is a "synthetic one, in which systems are built up out of units * * * Our discriminations are analyses * * * 'In first making acquaintance with an object we respond to it as an undifferentiated whole; later we come to make specialized responses to various parts and aspects of it; but it is the fact that it can be still responded to as a whole that *keeps these specialized movements together in a single system*, and thus gives the object its unity. An orange, or a chair, or a tree, is a single object, and not a mere aggregate of qualities and parts, because it can be reacted to as a whole, and because every one of the movements involved in attending to its parts is associated with the movements of reacting to the whole object.'" (My italics.) [46, pp. 87-88] Miss Washburn quotes from her earlier work [45].

We are in complete agreement with the first part of this statement. However, Washburn, in our opinion, merely *postpones atomism*: the original whole shortly is *broken up*, and must be *held together*. The forces controlling Gestalten are merely those of experience. Thus, "Motor psychology can explain the facts of perception which the configurationist merely describes. Take, for instance, the phenomena of ambiguous figures, such as the outline cube, which may be perceived either as lying on the ground or suspended in the air; what the configurationists would call the more natural configuration is the former, but surely it is more natural because the reaction of sitting down on cubes occurs oftener than that of looking up at them." [46, p. 88.]

A view such as this fails completely to take into account Wertheimer's work with dot-figures [48]; the completions and rectifications of the visual

relation between tactual experience and kinesthetic 'feels'. We must consider its nature.

The old atomistic theory (a whipping-boy theory) used an old-fashioned association process, in which each point on the body's surface receives its 'local sign' by way of a specific motor engram. Dunlap's [15] view is so closely bound up with the reflex-arc concept, that it is difficult not to think of it as such a theory. However, such specifist views are beset with innumerable difficulties, and have been adequately dealt with elsewhere.

We assume that perception in the infant is somehow different from that in the adult. We have indicated we do not consider that the difference lies in the fact that the adult has pasted together more pieces of a jig-saw puzzle of discrete experiences, even where these arise out of an original cohesion (Washburn).

Let us outline below a possible sequence of perceptual development in the cutaneous (especially tactual) sphere. The 'stages' here given are based on the theories of Coghill and others on motor development, Koffka's description of the development of visual perception in the child and similar sources.[1]

The child's first view of things is an essentially homogeneous, diffuse, undifferentiated field (rather than a plethora of distinct, separate and unorganized items of color, intensity, etc.). Instead of a world which is gradually put gether from an original conglomeration by the operation of experience, we have the concept that the *original unity* is broken down by a series of cleavages (it is questionable but unimportant whether a 'unity' can ever be 'perceived'—perhaps we perceive, in the ordinary sense of the word, only *after* the first cleavages appear). This principle of development—the parts differentiating out of the whole—has become most familiar in connection with the development of action, where the work of Coghill [10] and his supporters and attackers is well known. The principle is far more readily and successfully observable in behavior than in

field that we find in hemianopsia, etc. The same can be said for auditory 'figures', which are temporal in nature.

In our opinion there can be no question of the reality of the phenomena of perception described by Wertheimer, Koffka, Köhler, Rubin and others, nor is there a more parsimonious way to understand their operations than in terms of 'dynamic self-distribution' (see, *e.g.*, Köhler, [30, p. 140]) of forms in the perceptual field. But we feel, nevertheless, that a kind of motor theory, already briefly sketched, differing from Dunlap's or even Washburn's, is necessary to explain form-perception in tactual (and presumably thermal) sensitivity. What characteristics of the development of perception must it meet harmoniously?

[1] For a related discussion see Werner, [47] especially Buch II, Teil I.

perception, since we can receive no reports on visual organization either from the fetus or the infant.

The first and fundamental cleavage is described by the term 'figure and ground'. The first object seen is not produced by a welding of distinct impressions, but by its emergence from the undifferentiated global mass to become *figure against ground.* (Rubin). "* * * the first phenomena are *qualities upon a ground* * * * they are the simplest *mental configurations.* The phenomenal appearance in consciousness divides itself into a given quality, and a ground upon which the quality appears—a level from which it emerges. It is, however, a part of the nature of a quality that it should lie upon a ground, or, as we may also say, that it should rise above a level." [28, p. 131]. All later development is to be considered as further differentiation of the visual field, producing, by permanently effective cleavages, the familiar organizations of the adult. The nature of the final product is, of course, (in the Gestalt view), largely dependent on *given* characteristics of the nervous system.

If the laws of perception are (as Koffka claims), the laws of the entire nervous system, they must apply to the thermal senses. If we assume that these senses are (perhaps for biological reasons of inutility) *untrained* in form perception, we should expect only the simpler cleavages: such as the appearance of figure against ground. We should not expect 'good form', and the unambiguous operation of the internal forces any more than in the early stages of visual development. "* * * it is not the simplest of geometrical forms, but those biologically the most important, which are first evident in infantile perception." [28, p. 289]. *Ground* in the thermal field is somewhat different from that in vision, in that absence of adequate stimulation does not yield experience of the nature of black, but simply nothing. The differentiation of figure and ground is then likely to be more complex, because the ground *like that of vision,* is probably the entire body-image [Schilder, 38].

If the rough analogy with vision holds true, the perception of clear, bounded geometric figures would be the last and most highly developed stage of our cleavage series. The simplest figure might be the differentiation of one sub-whole in the bodily field from the rest, that is, *e. g.*, a 'warm limb'. Of about the same level of complexity would be the report of warmth of *any* region of the body, as when one faces a fireplace, against the more general 'I am warm'. The ability to *know* (in terms of the body image) the *place* that is warm

might then be safely considered as a criterion for this stage of differentiation. The next stage might be the ability to determine *size;* at first in terms of familiar extents of the body surface, later, on the basis of knowledge, converted into objective measures of size. We may consider the next higher form of discrimination as occurring when we have a further differentiation within the figure-region (the localized region of warmth or cold). That is, we now have cleavages *within* the figure[1] where before there was simply differentiation of the figure from the ground. In the course of further development we should expect the appearance of *shape* in very gross terms: the possibility of saying, *e. g.*, that 'this warmth extends more in *this* direction of my body than along that'; an adult is likely to phrase this in a sophisticated way, such as 'longer than it is broad', or, even, on the basis of experience with visual patterns, 'probably an ellipse of a rectangle'. The finer differentiations that would follow, if our analogy is correct, would be a sharpening of *boundaries* (in terms of the dynamics of the field, the heightening of tensions and gradients), clearer and more differentiated forms.

If this hypothetical but systematic series of deductions from the original hypothesis has at least theoretical justification, it is of interest to reexamine Tables XII-a and -b, XIII-a and -b and XV, for our experiments where 'free' report was used. Here an analysis was attempted in the terms just outlined; the data show a rather meaningful progression in the frequency with which reports corresponding to the successive 'stages' occur. There is a suggestion of a regular drop in the frequency of reports in each succeeding category. The fact that this progression is imperfect may be laid to the comparatively small number of items, and the difficulties in classification.

The plausibility of this analysis would lead to the view that we are dealing with a sense modality which has the same potentialities for spatial differentiation as vision, except for the great superiority of vision in terms of training and its superior equipment in density of receptors, and accessory apparatus, such as the lens. Anatomical facts make it certain that, at best, the final 'trained' ability would resemble that of the tactual rather than the visual sense.

Why, then, the necessity of a motor theory? Let us make it clear that we do not believe that the successive cleavages that we have mentioned are *made by* manipulation and motor activity: we do hold that kinesthesis *makes them possible.* We hold with Wertheimer

[1] 'Figure' is used here to indicate the figure-ground relationship; not as a synonym for 'form' or 'shape', as earlier in this paper.

and others that the *kinds* of cleavage and of organization of sensory experience are dependent on the *kinds* of individuals human beings are, and the forces operating in the perceptual apparatus *are such* that they follow the laws of figure-ground organization, *Prägnanz,* etc. The role of experience and motor activity, as we conceive it, is, first, to make the distinction between 'me' and 'world'; 'figure' and 'ground', etc. (much as Washburn says) but the organization of the field each time a new cleavage is made, is a perceptual function, following the laws of perception: the organization does *not* necessarily follow the lines of manipulation, as Washburn says. For instance, 'A' is as easy to pick up as '☆', yet hemianopics would see the star complete when half of it was in the blind field, not so for the 'A'.[1]

In considering the perceptual field of *touch,* we follow Goldstein [2] in the view that *vision and kinesthesis* organize the field: with no movement there would be no field; with no vision there would be no organization as we know it. The organized field in the touch-sense depends on the body-image, which is a construct; movements *of the body,* and touching various parts of the body *with the limbs* establish the limits and regions of the body when vision is operative and can 'form the image'. Ahlmann's and Gelb and Goldstein's work show that without such organization the 'cleavages' are absent: except for accurate *reflex* localization, the individual who is blind or who is suffering from a brain lesion of the type Gelb and Goldstein studied, is as helpless as an infant in localizing and describing tactual experiences. If he makes complete or incipient movements *of* or *to* the region involved, he is able to localize—but the body-image is lost. Later cleavages take place only in the presence of an intact body-image.

On this basis, we should suppose that the thermal senses have not developed beyond the stage of very gross spatial discrimination (that we found) only because of their biological inutility.[3] In every-day life the function of these modes of experience is, precisely, to render quantitative information regarding the temperature of the environment and merely gross, diffuse cues to the limits of the warmth or cold. We may supplement this rather *post hoc* statement by pointing out that the necessary combination of specific, localized thermal stimulation and appropriate movement hardly occurs: most of the shifts

[1] Cited from Fuchs by Koffka [29 p. 146 f.]

[2] See especially [22]. Also discussion by Katz [26] and Schilder [38].

[3] This would not be true if the possibility that we mentioned before of the *diffuse innervation* of warm and cold is a fact.

in thermal energy that we encounter outside the laboratory are diffuse, and usually involve the whole body, or large portions of it. Nor do they often occur without the presence of simultaneous tactual experiences, which apparently are 'dominant' in the complex.

We have sketched a general theory which would satisfactorily account for tactual form perception, and presumably, under the proper conditions, for thermal form perception.

The proper conditions, if this theory is valid, mean the simultaneous occurence, in an individual with normal vision, of physically localized thermal stimulation and of movements which serve both to localize the boundaries of the warmth or cold and to separate distinctly the portion of the body stimulated from the entire receptor field—i.e., the '*body-image*'. The failure of our training series to produce any greater accuracy than in those series where the opportunity for learning was limited, would be readily explainable on this basis, since a fundamentally inadequate type of training was used. In each case the experimental region was completely immobilized and the possibility of *movement*, which is all-important here, we deliberately excluded.

The view here presented grows out of our experimental work and may serve to explain our results, although *it is not a necessary deduction* from them. One of its virtues is that in turn it suggests a number of experiments by which it might stand or fall. Our own experiments may receive the credit of making clear what facts must be explained and the type of theory that may be adequate.

One crucial experiment that suggests itself requires pathological material. If we could arrange to experiment with a patient who had lost the touch sense and who, otherwise, had retained normal sensitivity and had no motor-kinesthetic impairment, we could conceivably expect that the usually 'ground' experiences of the thermal senses would now rise to the status of 'figure' and benefit from the motor training ordinarily associated with touch, thus permitting the cleavage process in its successive stages. If the same experimental arrangements were used as in the present survey, we should expect, with such patients, to find positive results, *i.e.*, reports of patterns demonstrably consonant with the stimuli. Such a study is waiting at present on the discovery of a suitable pathology.

The second experiment which should be expected to demonstrate the accuracy of the theory would employ normal subjects, but would take account of the necessity for movement. For instance, a beam of warmth, perhaps an inch in diameter, could be employed, the subject being blindfolded and instructed how to move his hand in the path of the beam. He might thus be able to 'trace' the outline of the beam and determine its nature. This would be comparable to the experiments in 'active touch', success in which field, in this view, would be conceived as a necessary prerequisite for successful 'passive touch'. These may serve as examples of the possibilities deriving from the 'motor-cleavage theory'. We should expect, moreover, that

after the training in either of the two cases just outlined, the crucial elements we considered in connection with Koffka's statement would be demonstrable.

In this theoretical consideration we should elaborate further the question of 'polarity': the 'objectification' or 'subjectification' of experience, that we mentioned at the close of the last chapter. Katz, and others whose work he summarizes, have considered the touch sense as *bi*-polar, *i.e.*, capable of either objective or subjective reference, while vision has been thought of as necessarily objective and temperature experiences as *primarily* subjective.[1] We should like in this connection to point to the phenomena of *constancy* (for color, size, etc.) in vision, in which it has been fairly successfully demonstrated that two *poles* are operative; according to Henneman [25], it is possible to shift between them with training. These poles have also been described as 'subjective' and 'objective' although using the words in a somewhat different sense from that we have just employed. The objective pole represents complete color constancy in which shifts in the stimulus situation are 'taken into account' and the object is perceived in its 'real' appearance (the white cow in deep shade still looks white in accordance with the actual albedo). Vision usually tends toward this pole: in other words, it is the ultra-objective sense. We should like to suggest very tentatively that both kinds of poles might be considered as phenomena of the same order, and that the visual constancies may belong in our larger continuum. We may bring in again the concept of 'cleavage'. The very first step, we would say, would be the establishment of the cleavage between 'world' and 'me'. This apparently is most easily and earliest accomplished in vision: the implication, for which we have no evidence, is that very early in the infant's existence vision carries a subjective reference. In fact, there *is*, as yet, no 'objective'. Because of the function of vision as a distance receptor and its ability to present constantly changing and at the same time sharply outlined experiences (in connection with which the free movement of the head and eyes is of indubitable significance), the objective pole quickly becomes dominant and finally exclusive. The poles in constancy represent a later cleavage[2] through which the objective world achieves an existence in a sense independent of specific stimuli. In the other senses (with the

[1] It is clear that the 'introversion' and 'extroversion' of perception is dependent, in part, on 'what I want to know' about the world around me. But the impossibility of forcing a true self-reference in visual experience, and the relative difficulty of achieving a genuine object-reference in temperature experiences seems clear enough.

[2] Brunswik [7] found an increase in constancy between the ages of 3 and 9.

possible exception of audition) this later cleavage does not occur; but merely the primary cleavage between self and not-self.

If this interpretation is correct we should rule out the suggestion we made in Chapter Four that the principle of polarity might make it impossible for form perception ever to occur in the thermal senses since we should now regard the polarity not as a *necessary* characteristic of a sense-department, but rather as a fact which is characteristic of the stage of development the modality has reached.

There are obvious gaps, but we have, up to this point, developed a fairly general theory of *cutaneous perception* into which a number of facts from diverse sources may be fitted, it seems, without essentially altering them. Its only virtue at present is that it is a *possible* explanation of a variety of facts, including the findings of our experiments, and that it is, at most points, susceptible of experimental verification: it suggests many experiments, a few of which have been mentioned.

CHAPTER SIX—SUMMARY AND CONCLUSIONS.

We have reported twelve experiments, each directed toward a phase of the problem of form perception in the thermal senses (the experiments are summarized individually at the beginning of Chapter Five). We wished to determine whether form perception was demonstrable, and to study the laws governing such perception in an 'untrained' modality. The first experiment (in the cold-sense) and the others in the warm-sense, despite the use of three different types of apparatus, and several forms of procedure, failed to reveal the slightest objective accuracy in discrimination of thermal geometric form. Experiments in which the instructions to the *O*s did not specifically call for report of shape showed that while such descriptions were unusual, they did occur in some instances. Using large surfaces of the body proved no more successful, and demonstrated also the strong tendency toward the generalization of warmth rather than the discrimination and field-tensions necessary for the perception of patterns. Certain gross patterning was evident, however, in terms of crude spatial differentiation.

A theory is suggested which, making use of some principles of Gestalt theory and of 'motor' theory, would explain our results in a 'genetic' fashion; describing the respective differences between vision, touch and temperature (beyond those determined by differences in basic structure) as differences in ease and opportunity for the occurrence of successive 'cleavages' in the originally undifferentiated field. It is suggested that the cleavages of greatest importance are, in order, the distinction between self and not-self, between subjective and objective attribution of experience, between figure and ground and, successively, discrimination of location, size, orientation (of an experience-mass on the skin) and, finally, of bounded areas which may ultimately be perceived as clear geometric forms. In the later stage the laws of 'good shape' found in vision should be demonstrable. It is thought that motor processes, in combination with vision, play the essential role in the operation of 'experience' in producing the successive stages of perception.

The theory outlined is not a necessary conclusion from the experiments, but is regarded as the most fruitful one in the direction of further research.

BIBLIOGRAPHY

1. Ahlmann, W. Zur Analysis des optischen Vorstellungslebens. Ein Beitrag zur Blindenpsychologie. *Arch. f. d. ges. Psychol.*, 1924, 46, 193-261.
2. Bentley, M. The new field of psychology. New York: Appleton-Century, 1934. Pp. xvi + 439.
3. Bishop, G. H. and P. Heinbecker. The afferent functions of non-myelinated or C fibers. *Amer. J. Physiol.* 1935-6, 114, 179-193.
4. Boring, E. G. The physical dimensions of consciousness. New York: Century, 1933. Pp. xii + 251.
5. Bose, S. K. and N. L. Kanji. Perception of form by passive touch, *Indian J. Psychol.*, 1926, 1, 93-101.
6. Bromberg, W. and P. Schilder. On tactile imagination and tactile after-effect. *J. Nerv. and Mental Dis.*, 1932, 76, 1-24, 133-155.
7. Brunswik, E. Zur Entwicklung der Albedowahrnehmung. *Zsch. f. Psychol.*, 1929, 109, 40-115.
8. Carr, H. A. An introduction to space perception. New York: Longmans, Green, 1935. Pp. xi + 413.
9. Clark, D., J. Hughes and H. S. Gasser. Afferent function in the group of nerve fibers of slowest conduction velocity. *Amer. J. Physiol.*, 1935-6, 114, 69-76.
10. Coghill, G. E. Anatomy and the problem of behaviour. Cambridge: University Press, 1929. Pp. xii + 113.
11. Dallenbach, K. M. 'Subjective' perceptions. *J. Exper. Psychol.*, 1921, 4, 143-163.
12. Dallenbach, K. M. The temperature spots and end-organs. *Amer. J. Psychol.*, 1927, 39, 402-427.
13. Dimmick, F. L. On the localization of pure warmth sensations. *Amer. J. Psychol.*, 1915, 26, 142-150.
14. Drury, M. B. Progressive changes in non-foveal perception of line patterns. *Amer. J. Psychol.*, 1933, 45, 628-646.
15. Dunlap, K. The biological basis of the association of ideas and the development of perception. *Psychobiol.*, 1920, 2, 29-53.
16. Ebbecke, U. Uber die Temperaturempfindung in ihrer Abhängigkeit von de Hautdurchblutung und von den Reflexzentern. *Pflügers Arch., f. d. ges. Physiol.*, 1917, 169, 396. (Cited by Katz, 27).
17. Fehrer, E. V. An investigation of the learning of visually perceived forms. *Amer. J. Psychol.*, 1935, 47, 187-221.
18. Franz, S. I. Diffusion effects following localized tactile training. *Publ. Univ. Calif. Los Angeles, Educ., Phil., Psychol.*, 1933, 1, 129-135.
19. Franz, S. I. Training in touch perception and cross education. *Publ. Univ. Calif. Los Angeles, Educ., Phil., Psychol.*, 1933, 1, 121-128.
20. Franz, S. I. and S. Kilduff. Widespread improvement in tactile discrimination following localized training. *J. Gen. Psychol.*, 1934, 10, 469-471.
21. Gasser, H. S. and J. Erlanger. The role played by the sizes of the constituent fibers of a nerve trunk in determining the form of its action potential wave. *Amer. J. Physiol.*, 1927, 80, 522-547.
22. Goldstein, K. and A. Gelb. Uber den Einfluss des vollständigen Verlustes des optischen Vorstellungsvermögens auf das taktile Erkennen. *Zsch. f. Psychol.*, 1920, 83, 1-94.

23. De Gowin, E. L. and F. L. Dimmick. The tactual perception of simple geometrical forms. *J. Gen. Psychol.*, 1928, 1, 114-122.

24. Heinbecker, P., G. H. Bishop and J. O'Leary. Analysis of sensation in terms of the nerve impulse. *Arch. Neur. and Psychiat.*, 1934, 31, 34-53.

25. Henneman, R. H. A photometric study of the perception of object color. *Arch. Psychol.*, 1935, No. 179, Pp. 88.

26. Katz, D. Der Aufbau der Tastwelt. *Zsch. f. Psychol.*, Ergänzungsband 11, 1925, Pp. xii + 270.

27. Katz, D. The world of colour. London: Kegan Paul, 1935, Pp. xvi + 300.

28. Koffka, K. The growth of the mind. New York: Harcourt, Brace, 1925. Pp. xvi + 383.

29. Koffka, KK. Principles of gestalt psychology. New York: Harcourt, Brace, 1935. Pp. xi + 720.

30. Köhler, W. Gestalt psychology. New York: Liveright, 1929. Pp. x + 403.

31. Langfeld, H. S. and F. H. Allport. An elementary laboratory course in psychology. New York: Houghton Mifflin, 1916. Pp. xvi + 147.

32. Major, D. R. Cutaneous perception of form. *Amer. J. Psychol.*, 1898-9, 10, 143-147.

33. Martin, A. H. Light pressure contact. *Australas. J. Psychol. & Philos.*, 1934, 12, 150-151.

34. Nafe, J. P. and K. S. Wagoner. I. The experiences of warmth, cold and heat. *J. Psychol.*, 1936, 2, 421-431.

35. Oberto, S. La soglia di rettilineità nel campo tattile puro. *Arch. Ital. Psicol.*, 1936, 14, 85-95.

36. Rosenbloom, B. L. Preliminary study of configurational perception of tactual stimuli. Master's essay, Columbia University, 1927.

37. Rosenbloom, B. L. Configurational perception of tactual stimuli. *Amer. J. Psychol.*, 1929, 41, 87-90.

38. Schilder, P. The image and appearance of the human body. *Psyche Monog.*, No. 4. London: Kegan Paul, 1935. Pp. 353.

39. Seward, J. P. Jr. The effect of practice on the visual perception of form. *Arch. Psychol.*, 1931, No. 130, Pp. 72.

40. Stone, L. J. and K. M. Dallenbach. Adaptation to the pain of radiant heat. *Amer. J. Psychol.*, 1934, 46, 229-242.

41. Stone, L. J. An experimental study of perception of thermal patterns. Master's essay, Columbia University, 1935.

42. Strughold, H. and R. Porz. Die Dichte der Kaltpunkte our der Haut des menschlichen Körpers. *Zsch. f. Biol.*, 1930-31, 91, 563-571.

43. Toulouse, E. and N. Vaschide. Nouvelle méthode pour la mesure de la sensibilité stéréognostique tactile. *C. R. Acad. des Sci.*, 1900, 131, 128-130.

44. Washburn, M. F. Gestalt psychology and motor psychology. *Amer. J. Psychol.*, 1926, 37, 516-520.

45. Washburn, M. F. Movement and mental imagery. New York: Houghton Mifflin, 1916. Pp. xv + 252.

46. Washburn, M. F. A system of motor psychology. In C. Muchison (ed.) Psychologies of 1930. Worcester: Clark University Press, 1930. Pp. 81-94.

47. Werner, H. Einführung in die Entwicklungspsychologie, 2 aufl. Leipzig: Barth, 1933. Pp. vii + 424.

48. Wertheimer, M. Untersuchungen zur Lehre von der Gestalt. *Psychol. Forsch.*, 1923, 4, 301-350.

49. Woodworth, R. S. Psychology. (third ed.) New York: Holt. 1934. Pp. xiv + 546.

50. Zigler, M. J. and R. Barrett. A further contribution to the tactual perception of form. *J. Exper. Psychol.*, 1927, 10, 184-192.

51. Zigler, M. J. and K. M. Northup. The tactual perception of form. *Amer. J. Psychol.*, 1926, 37, 391-397.